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ENGINEERING:

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Aveling & Porter, Ltd.,
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2581

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CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
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See advertisement page 19.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C.2.
See half-page Advert. last week and next week. 2087

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STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited,
BIRMINGHAM. 2530
See Advertisement last week, page 13.

Spencer-Hopwood & Kirke
PATENT BOILERS *See Page 40, Feb. 27.* 1994
Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
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Hammers, Presses, Furnaces,
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Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd.,
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of 1834
PLANT AND MACHINERY
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Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 2367
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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement, page 33, Feb. 27.

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PASSENGER AND CARGO STEAMERS.
SHALLOW DRAFT VESSELS.
2276

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Worm Wheels cut up to 13 ft. diam.
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Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
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PRESSURE AIR, STEAM
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Naval Outfits a Speciality, also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
Supplied to the British and other Governments.
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GEAR WHEELS up to 10 ft. diameter.
FLY ROPE and SPUR DRIVING WHEELS up to 26 ft. diameter.
BRICK and CLAYWORKING MACHINERY of all kinds.
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Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising London." —Great Eastern Road, Stratford, E. 15. 1794

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London Office—12, Victoria Street, S.W.
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CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 2033

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AND PROPULSION PROBLEMS.
Special designs only.
"Circulation Theory."
Akimoff Propeller Company,
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ENGINES, 500 Kw., Dynamos 230 Volt D.C. Brush, Parsons 600 Kw. EXHAUST TURBINE SET 220 Volt, D.C., with complete condensing plant. Very low price.
JENNINGS, 2402
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John Bellamy Limited
MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 1216
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

IRON & STEEL
Tubes AND Fittings
AND
Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW BIRMINGHAM LONDON.
See Advertisement, page 90. 2584

Peter Brotherhood Ltd.,
PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 1475
See Advertisement, page 51, Feb. 27.

"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS
Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD., 2738
E. GREENWICH, LONDON, S.E.10 (& at Birmingham)

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A.C. Motors in Stock—
Suitable for 3 phase; 50 cycles; 400/440 volt.
Very fine 250 HP., SLIP RING MOTOR by Westinghouse, 325 revs; brush lifting and short circuiting device. Oil-immersed Circuit Breaker and Liquid Starter, by Ellison.
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Two Almost New 75 HP. SLIP RING MOTORS, by Westinghouse, 480 revs. With brush lifting and short circuiting device. Oil-immersed Switches and Liquid Starters, by Erskine Heap.
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(Established 1804.)
BUILDERS of RAILWAY CARRIAGES & WAGONS
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Telephone: 7424 Central.
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FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES } Row's Patents.
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SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

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LAND AND MARINE
YARROW BOILERS.
2277

Matthew Paul & Co., Ltd., 2212
LEVENFORD WORKS, Dumbarton.
See Full Page Advt., page 58, Feb. 27.

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works and Showrooms: BIRMINGHAM.
See Advert., page 36, Feb. 27. 3196

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T. SUMMERSON & SONS, LIMITED,
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68 ACRES OF GROUND AND BUILDINGS, suitable for works, at Inchinnan, on the main road between Glasgow and Greenock.
One building, length 250 ft. by 150 ft., height 44 ft. to eaves, structure of brick and steel, lit from roof, contains approximately 37,500 sq. ft. floor space.
One building, in several bays, 330 ft. long at the longest part 268 ft. broad, height one part 24 ft. 6 in. to eaves, other part 16 ft. to eaves, structure of brick and steel, lit from sides and roofs, granolithic floors, mechanically heated, contains approximately 83,000 sq. ft. floor space.
One building 320 ft. long by 160 ft. broad, height, 16 ft. 9 in. to eaves, with small annex 50 ft. by 30 ft. structure of brick and steel, granolithic floors, lit from sides and roof, mechanically heated, approximately 53,000 sq. ft. floor space.
Electric power is laid into each of these buildings from the Clyde Valley Power Station, also water supply.
For further particulars apply to:—
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STATIONARY DIESEL ENGINES with accessories, as delivered from the makers under Peace Treaty; also Dynamos for same. All spare parts in stock.—HICK-DIESEL OIL ENGINES LTD., 70, Queen Victoria Street, E.C. 4. 2527

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SPECIAL MACHINERY, try
THOMAS HUNT & SONS,
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MECHANICAL ENGINEERS,
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Undertake SPECIAL MACHINE WORK of any description.
WELL EQUIPPED SHOP.
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For Paraffin and Crude Oil
Sizes 1½ B.HP. and upwards.
Petters Limited, Yeovil.
Sizes 25 to 500 B.HP.
Vickers-Petters, Ltd., Ipswich
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The Manchester Steam Users ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2701

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Draughtsmen, before

Negotiating with Government Departments in connection with any post, please communicate with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 98, St. George's Square, London, S.W.1. G 758

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in the lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 77, Millgate Building, Manchester. 2676

TENDERS.

HOPPER BARGE.

THE TRUSTEES OF SHOREHAM HARBOUR invite

Tenders for the Supply and

DELIVERY of a suitable NEW WOOD HOPPER BARGE, capable of carrying about 200 tons of Dredged Material. Full particulars, including Plans, Specifications and Form of Tender, to be sent to the undersigned and to arrive by or before the first post on MONDAY, the 16th day of March, inst.

The Trustees do not bind themselves to accept the lowest or any Tender.

CRANFIELD BAGULEY,
Clerk to the Trustees.

Harbour Offices,
Southwick, Brighton.
3rd March, 1925. H 417

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply of :—

1. STEEL FISHPLATES.
2. FISHBOLTS, NUTS and WASHERS.
3. STEEL BEARING PLATES for F.B. Rails.
4. STEEL CRANKED FISHPLATES.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked :—"Tender for Steel Fishplates," or as the case may be, must be left with the undersigned not later than Twelve Noon, on Friday, the 20th March, 1925.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10/- for each copy of Specification No. 1, 5/- for each copy of Specification No. 2, and 2/6 for each copy of Specification Nos. 3 and 4.

Copies of the Drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. ROBERT WHITE & PARTNERS, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France.
3rd March, 1925. H 413

ADMINISTRATIVE COUNTY OF LONDON.

NORTH-WESTERN STORM RELIEF SEWER.

CONTRACT No. 2.

The London County Council invites

Tenders for the Construction

of a 7 ft. 6 in. and 8 ft. 6 in. internal diameter SEWER in Brickwork or Cast Iron, of a total length of about 7180 feet, from Kilburn Park Road, to Clarendon Road; also a 4 ft. 6 in. internal diameter BRANCH SEWER in Brickwork of a total length of about 2780 feet, from Ladbroke Grove to Tavistock Crescent, and a 5 ft. 0 in. internal diameter BRANCH SEWER, in Brickwork of a total length of about 5340 feet from Scrubbs Lane to Cornwall Road, including Weir Chambers, Tumbling Bays, Manholes, Ventilators, Side Entrances, etc., in the Metropolitan Boroughs of Paddington, Kensington and Hammersmith and the Urban District of Willesden.

Persons desiring to submit Tenders may obtain the Form of Tender and Contract, Specification, Bill of Quantities and Drawings on application, on and after Monday, 2nd March, 1925, to the Chief Engineer of the Council at the Old County Hall, Spring Gardens, S.W. 1, upon payment of the sum of £10. This amount will be returnable only if the tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected before payment of the fee.

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after Twelve noon on Tuesday, 24th March, 1925, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

MONTAGU H. COX,
Deputy Clerk of the London County Council.
H 375

METROPOLITAN ASYLUMS BOARD.

The Board Invite

Tenders for the Removal of

EXISTING HEATING APPARATUS and the PROVISION and FIXING of NEW HEATING APPARATUS at Caterham Mental Hospital, Caterham, Surrey, in accordance with the Specification and Drawings prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in Chief. The Specification, Drawings, and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m., on Thursday, 5th March, and can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawings have been returned.

Tenders, addressed as noted on the Form, must be delivered at the Office of the Board not later than 2.30 p.m., on Wednesday, 25th March, 1925.

G. A. POWELL,
Clerk to the Board. H 395

METROPOLITAN ASYLUMS BOARD.

TO ELECTRICAL ENGINEERS.

The Board invite

Tenders for Extensions to the

ELECTRIC LIGHTING INSTALLATION at the North Western Ambulance Station Lawn Road, Hampstead, N.W.3, in accordance with the Specification and Drawings prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specification, Drawings and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m., on Friday, 6th March, and can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawings have been returned.

Tenders, addressed as noted on the Form, must be delivered at the Office of the Board not later than 1.30 p.m., on Wednesday, 25th March, 1925.

G. A. POWELL,
Clerk to the Board. H 396

THE DERWENT VALLEY WATER BOARD.

PIPE TO FILTERS.

The Derwent Valley Water Board is prepared to receive

Tenders for the Laying of

about 10,000 yards of 48 inch STEEL PIPES, lined with concrete, and the Valves, Stream Crossings, etc., connected therewith.

The Specification and Schedule of Prices and copies of the Drawings may be obtained on application to Mr. S. B. WYNNE, M.I.C.E., Engineer to the Board, at these Offices, on and after Monday, 9th March, on payment of Two Guineas, which will be returned on receipt of a *bona fide* Tender and the documents furnished by him.

Sealed Tenders, enclosed in the envelope supplied, with the documents, to be delivered not later than Nine o'clock, on MONDAY morning, the 23rd of March.

The Board will not be bound to accept the lowest or any Tender.

O. B. STEWARD,
Clerk to the Board.

Bamford, near Sheffield.
23rd February, 1925. H 357

CLYDE NAVIGATION.

TO SHIPBUILDERS.

STRAM HOPPER BARGES.

The TRUSTEES of the CLYDE NAVIGATION invite

Tenders for Two Twin-screw

STEAM HOPPER BARGES of 1200 tons capacity, or alternatively, of 1500 tons capacity.

On and after 9th instant, Drawings may be seen and copy of the Specification and Form of Tender obtained, on application at this Office to Mr. DANIEL FIFE, Mechanical Engineer, on payment of £3 3s., which will be refunded on receipt of a *bona fide* Tender.

Sealed Tenders, marked "Tender for Hopper Barges," to be lodged with the undersigned not later than Noon on MONDAY, 6th April next.

The Trustees may not accept the lowest or any Tender.

T. R. MACKENZIE,
General Manager and Secretary.

16, Robertson Street, Glasgow,
5th March, 1925. H 439

METROPOLITAN ASYLUMS BOARD.

TO ENGINEERS.

The Board invite separate

Tenders for :—

(A) GENERAL ENGINEERING WORK, including Centralised Heating and H.W.S. Systems, Steam Mains, etc., LAUNDRY and KITCHEN EQUIPMENT.
(B) INSTALLATION of ELECTRIC LIFTS,
(C) INSTALLATION of BAKER'S OVEN,
(D) INSTALLATION of ELECTRIC LIGHTING, AUTO. TELEPHONES, FIRE ALARMS, ELECTRIC CLOCKS, etc.,

at the Grove Park Institution, Lee, S.E. 12, each in accordance with the Specification and Drawings prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specifications, Drawings, and Forms of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m., on Thursday, 12th March, and can then be obtained upon payment of a deposit of £1 in respect of each work. The amounts of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawings have been returned.

Tenders, addressed as noted on the Form, must be delivered at the Office of the Board not later than Ten a.m., on Tuesday, 31st March, 1925.

G. A. POWELL,
Clerk to the Board.
March, 1925. H 419

APPOINTMENTS OPEN.

Applications are Invited for

a REPRESENTATIVE in London for an Engineering Firm in the North. Must be an Engineer and have a thorough knowledge of power-house requirements and to be able to negotiate enquiries and follow up Tenders with the leading Consulting Engineers and Export Houses in London.

Applications will only be considered from fully qualified men, and should include age and experience, also salary required.—Address, H 371, Offices of ENGINEERING.

Works Manager Wanted for

large Structural works in London.

Must have held a similar position and be able to handle men and turn out work expeditiously.

State age, experience and salary required.

Address, H 387,
Offices of ENGINEERING.

Gentleman Required for

London Office of important Steel Tube Company, as Manager. Must be well-known to buyers and purchasing agents of Engineers, Railway Companies and Export Houses.—Address, giving full particulars of experience, salary required, etc., H 421, Offices of ENGINEERING.

Engineering Staff Employ-

MENT CONSULTANT (spare time), Required by City firm. Nominal investment £100/150, fully secured. Particulars at interview.—Address, H 415, Offices of ENGINEERING.

Architect Required by

the GOVERNMENT of SIERRA LEONE, in the PUBLIC WORKS DEPARTMENT, for two tours of not less than 12 nor more than 18 months' continuous residential service. Salary £600 a year. Free quarters and passages and liberal leave on full salary. Candidates, aged 28-35, should have served articles with a Member of the Royal Institute of British Architects, and have passed the examination qualifying for Associate Membership of that Institute, or possess the diploma of some recognised college which is accepted by that Institute as exempting candidates from taking the examination of the Institute. Must be first-class Draughtsman, capable of designing and carrying out buildings, taking out quantities, preparing details and specifications, and must be competent to execute building surveys, set out buildings and lay out roads.—Apply, at once, by letter, stating age, qualifications and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, quoting M/13190. H 388

Engineer with knowledge of

Accounts REQUIRED to take charge of Cost Office in light Engineering Works. London district.—Address, giving details of experience, age, salary required, etc., H 427, Offices of ENGINEERING.

Chemical Engineer of Proved

ability in controlling chemical works employing low class labour REQUIRED at once. Must be thoroughly experienced in running machinery.—Reply, with full particulars of past experience, in confidence, and stating salary required, to BARNES AND FAWNS, LTD., 314/317, Moorgate Station Chambers, E.C.2. H 385

Constructional Engineers

REQUIRED in London area for factory development work; experienced in design of steel frame and reinforced concrete buildings and with knowledge of drainage, heating systems and building materials. Men with architectural pupilage and experienced in supervision of building work preferred. Only applications from London district considered.—Address, H 437, Offices of ENGINEERING.

Power Plant Engineers

REQUIRED in London area for factory development work; experienced in modern water tube boilers, turbines, reciprocating engines and auxiliary equipment; first-class technical and practical training essential. Only applications from London district considered.—Address, H 438, Offices of ENGINEERING.

Assistant Engineers

REQUIRED for the GOLD COAST GOVERNMENT CENTRAL PROVINCE RAILWAY CONSTRUCTION for a tour of 12 to 18 months' service with possible extension. Salary £480 rising to £720 a year by annual increments of £30. Field allowance of £90 a year whilst carrying out duties in the Colony. Free passages and liberal leave on full salary. Candidates, not over 40 years of age, must be fully trained Civil Engineers and be proficient in the use of the Transit and Level. Must have ability to do ordinary draughting and compiling estimates, and be able to set out work and generally supervise erection of concrete and steel work. Apply at once by letter stating age, qualifications and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W.1, quoting M/12449. H 389

Section Engineers (Four)

REQUIRED for the Construction Branch of the FEDERATED MALAY STATE RAILWAYS for three years' service with possible extension. Salary $400 a month, rising to $475 a month by annual increments of $25 a month, plus a temporary non-pensionable allowance of 10% which is liable to cancellation on revision, plus a commuted Field Allowance of $50 dollars a month. The exchange value of the dollar, in sterling, is at present fixed by the Government at 2s. 4d., but its purchasing power in Malaya at present is considerably less than that of 2s. 4d. in the United Kingdom. Free passages provided. On expiration of agreement a bonus of 4½ months' salary may be allowed provided the work and conduct of the person engaged has been in every way satisfactory. Candidates, age 22 to 38, unmarried, must have passed examination to qualify for Associate Membership of the Institute of Civil Engineers or hold equivalent professional qualifications, have served an engineering apprenticeship on a Home Railway, and prefera by possess some subsequent experience on railway construction or maintenance. In the event of the selection of a candidate who has not attained the age of 26, he will only receive a salary of $350 a month until he has attained that age.—Apply, at once, by letter, stating age and particulars of qualifications and experience to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, quoting at top of application M/13364. H 426

Wanted Marine Engineer,

with B.O.T. Certificate, for Motor Engines, or endorsement, for service in small motor vessel Red Sea Trade. Wages Rs. 375 plus Rs. 45 messing allowance, equivalent present rate of exchange to £28 2s. 6d. and £3 7s. 6d.—Write, stating full particulars, experience, etc., to THE HALL SHIPPING CO., LTD., 3-5, Tooley Street, London, S.E.1. H 340

THE CORPORATION OF TRINITY HOUSE.

APPOINTMENT OF ASSISTANT ENGINEER.

Applications are Invited for

the APPOINTMENT of an ASSISTANT ENGINEER. Age 28 to 35.

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Commencing salary £400 per annum, rising to £600 per annum, plus bonus.

Applications, stating age, qualifications and experience, accompanied by copies of not less than three testimonials, to be addressed to the SECRETARY, Trinity House, London, E.C. 3, not later than the 20th March, marked outside "Applications re Assistant Engineer." H 399

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age 25-30, unmarried, on a four years' agreement, with possible extension. He must have a good technical education, a regular training as a Civil Engineer and have a practical knowledge of Surveying, Levelling and Estimating, and at least three years' experience in works of Water Supply. Preference will be given to an Assistant who has passed the examination of the Institution of Civil Engineers, as Assoc.M.Inst.C.E., The Testamur by examination of the Institution of Municipal and County Engineers will be an advantage.

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DRAUGHTSMAN, Constructional, used to Steel-Frame Buildings, Design and detail, theoretical knowledge essential. Age 25 to 35.—Reply, giving full details of experience and salary required, to CHIEF ENGINEER, DREW-BEAR PERKS & Co. Ltd., Wellington Road, Battersea, S.W. H 423

Messrs. Reavell & Co., Ltd.,

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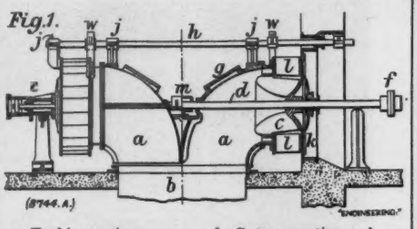
SMALL HYDRO-ELECTRIC UNITS.

DURING the past decade great advances have been made in the development of the hydraulic turbine. These have from time to time been recorded. A number of descriptions of the larger plants have appeared, but the smaller units, those of 100-h.p. or so, have, perhaps, been sometimes neglected. As a matter of fact the improvements in design and construction of small units have represented an important advance, because small water powers are not always an attractive proposition, first, on account of the expense of development and, secondly, owing to the indifferent machinery offered by firms in the hydraulic turbine business in the past. Whilst for obvious reasons the most economical aspect of water-power development lies in the installation of high-power units generating electricity for distribution over wide areas, engineers and factory owners are commencing more fully to appreciate the wisdom of developing, when possible, the smaller water powers either for the purpose of assisting fuel plants or for the complete operation of a works or factory.

The recent improvements in the design and construction of small hydraulic turbines enable units to be obtained which will convert a much larger proportion of the available energy into power than formerly, while a higher rotational speed and improved methods of governing allow these units to be, in most cases, direct-coupled to generators, without the latter being unduly heavy or costly.

Some 30 years ago, a move was made in this direction in America with the introduction of the stock-pattern turbine. These turbines were put forward as general purpose machines; they were built mostly with Francis type runners, usually mounted vertically. They, no doubt, proved considerably superior to the old waterwheels and to the Jonval and Fourneyron turbines then in vogue. With a small range of sizes, makers, mostly American, offered machines to suit a wide range of head and discharge, but efficiency was a secondary consideration, while governing was crude and unreliable. As general purpose machines they served, and still serve, a useful purpose, but their comparatively slow speed, inefficiency, and unreliable governing render them entirely unsuitable for driving modern electrical machinery.

Fig. 1.



a. Turbine casing.
b. Draught tube.
c. Runner.
d. Shaft.
e. Outside bearing.
f. Coupling in power-house.
g. Access door.
h. Gate-operating rod.
j. Bearings for *h*.
k. Bulkhead.
l. Guide vanes or wicket-gates.
m. Centre bearing.
w. Gate-operating links.

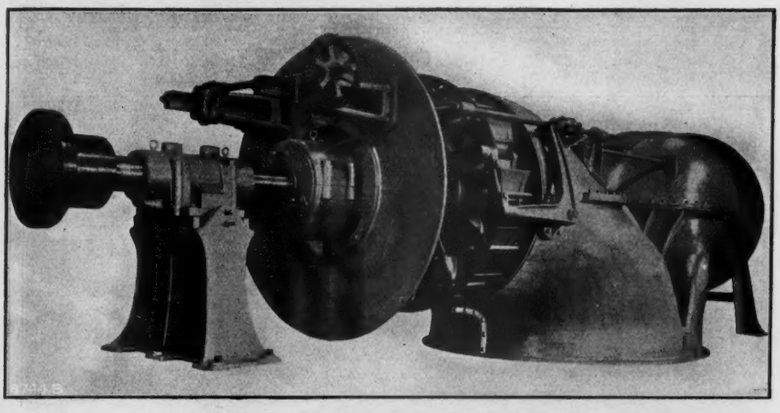


FIG. 2. FRANCIS TURBINE FOR OPEN FLUME.

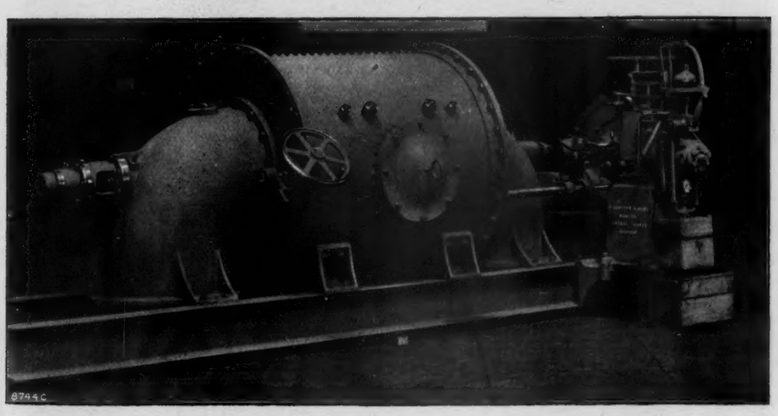


FIG. 3. 85-H.P. TWIN FRANCIS TURBINE.

These stock-pattern turbines were reaction turbines. The modern conception of a small reaction turbine is a very different proposition. In the first place the vertical shaft is, whenever possible, done away with, the gearing involved, unless a vertical generator is installed, being an undesirable feature for one reason. Speeds are considerably higher, the main efforts of designers in recent years having been directed to increasing runner speeds. Again, governing has been brought much nearer perfection, and the governing gear has been reduced from a more or less cumbersome "box of tricks" to a neat self-contained piece of mechanism, often showing considerable ingenuity in its design.

In the impulse class, improvement has mainly been directed towards closer governing. The installation of a small impulse turbine is generally a much simpler proposition than is the case with a reaction turbine, because the efficient operating head is generally higher. This means less water, smaller piping, a higher speed, usually a simpler governing problem and nearly always less costly incidental works. In fact, the impulse turbine, which in modern practice is the Pelton wheel, is, *prima facie*, a much more attractive proposition for a small power unit than any reaction turbine, but it is essentially suitable for high heads, and high heads are a comparatively simple problem for the hydraulic engineer. This cannot be said of low heads. Unfortunately, high heads are by no means common, and those seeking to develop small water-power plants have to be content, more often than not, with moderate and even very low heads. It is with the latter class of turbine that the greatest improvements have recently been made.

From what has been said it will be inferred that for high heads the Pelton wheel is the ideal unit. At the outset it should be stated that it is extremely difficult to define the difference between a high head and a low one, and the limits here given are not to be taken too strictly. Hydraulic turbines are operating to-day on heads from 5 ft. to 3,000 ft., but generally speaking the limits available for small plants will be between 10 ft. and 500 ft. Even within this range there is no definite line where an impulse turbine would be chosen in preference to a reaction one, and the question of "Reaction *v.* Impulse" turbine enters largely into the final choice of the unit; this was discussed in ENGINEERING dated February 2, 1923, page 129. It often proves, even with small units, a difficult matter to define just the head where an impulse turbine ceases to be superior to a reaction machine, and even if this could be done, local conditions might modify the decision, but generally speaking an impulse turbine would be installed wherever possible. That is to say, if a reasonable speed with a reasonable sized wheel can be obtained with the available quantity and head the Pelton, in its modern form, will prove an ideal power unit. In the reaction class the Francis turbine now holds the field. The Jonval machine of the parallel flow type was not a practical proposition in the hydro-electric field on account of its slow speed and difficulties of governing; the same remarks apply to the Fourneyron turbine of the outward flow class. The modern Francis turbine has been so considerably improved both as regards increase of speed, greater efficiency and closer governing that, except for exceptional conditions of head, it may be regarded as the chief alternative to the Pelton, and generally speaking, for lower heads than are suitable to the latter.

The Francis Turbine.—When conditions prove unsuitable for the Pelton wheel, which will be discussed in a following section, the Francis turbine in one form or another will generally take its place except for conditions of very low falls, which may warrant the installation of other types to be discussed. While the modern Francis turbine is a machine capable of very wide application and has been successfully installed for heads of from 8 ft. to 800 ft.; in the present connection the limits would generally be from 25 ft. to 250 ft., but the higher limit is by no means definite. There are, in the main, four types to be considered, that is: (1) The double runner type in steel case; (2) the single runner type is steel case; (3) the spiral cased type with single or double discharge; (4) the vertical type for very low heads.

The Francis turbine is classified as a mixed flow turbine. That is to say, the water enters radially inwards and leaves in a direction practically parallel with the shaft. This accounts for the somewhat peculiar form of runner. The water is led into the runner through a series of guides vanes. These vanes can move on pivots. Each pivot is connected to a control ring, which in turn is operated by the governor, the movement of the ring closing or opening the gates as the case may be. This arrangement of runner and pivoted gates, which form the chief features of the Francis design, may be set up in a variety of ways, and looked at as a whole one Francis turbine may appear to be very different from another, but the principle is the same.

Units for Moderate Heads, 20 ft. to 50 ft.—A common arrangement for a Francis turbine for moderate

heads is that shown in Fig. 1, the general construction being made clear from the reference lettering thereon. This turbine would be set in an open flume, the shaft *d* passing through a watertight bulkhead *k* into the power house. Fig. 2 shows a view of such a turbine. The open flume system is giving way wherever possible to the steel case, because the latter is generally a cheaper and more convenient arrangement. A unit of this class of British design, by Messrs. W. Gunther and Sons, is shown in Fig. 3, designed for developing 85 h.p. on a 20 ft. fall running at 375 r.p.m. It is direct coupled to an alternator, and on the right the oil pressure governor may be seen. This will be discussed later. It will be observed that while the turbines in Figs. 1 and 2 have central discharges the one shown in Fig. 3 has two quarter bend discharges.

Fig. 4 shows a turbine with one wheel and is an American design by the Allis Chalmers Company for developing 250 h.p. on a 39 ft. head, running at 450 r.p.m. It is, to all intents and purposes, half of the unit shown in Fig. 3, the single quarter bend discharge being seen just behind the governor. Another view of the same turbine is given in Fig. 5, showing the flange for the penstock connection and the butterfly control valve. This type of valve, it might be added, is quite suitable for small units, and it has the advantage of being easy and cheap to construct. These turbines may be taken as typical of classes 1 and 2.

Francis Runners in Spiral Case.—This type of turbine is very popular for heads of 50 ft. and over, but is also installed for lower heads. The arrangement of the mechanism of such a turbine is shown in Figs. 6 and 7. Runner *a* is mounted on shaft *b* in casing *c*. One side of the casing is closed by cover *d* and the other side by cover *e*, to which is bolted a quarter bend discharge piece *f*. The control gates are shown at *g*, the gate pins at *h*; *j*, *j* are the rocker arms which connect them to the control ring. To understand the principle of the pivoted guides more clearly reference should be made to Fig. 8. From this it will be clear that a circular movement of the control ring *a* will, through links *b*, turn gates *c* on the pivots *d*.

Fig. 9 shows a unit of this class with the end cover removed, exposing the wheel on the discharge side, and, incidentally, shows on the left a pressure relief valve as used on turbines of this class by the Allis Chalmers Company. The complete hydro-electric unit to which this turbine belongs is shown in Fig. 10, and is a good example of a self-contained installation, developing 50 h.p. on a 43 ft. head at 900 r.p.m.

It will be observed that for low heads the casing, as shown in Fig. 9, is large as compared with the wheel, and it is now quite usual to find it built of sheet steel on a framing.

Balancing.—A Francis turbine with two runners on the same shaft, or one double discharge runner is, like the double-inlet centrifugal pump, self balancing, but the single runner is not. That is to say there is hydraulic end thrust to be considered. This thrust can be taken by a thrust bearing, and with the introduction of the Michell system there is little trouble with thrust bearings. The more usual arrangement, however, is some form of hydraulic balance. Under one system the space behind the runner is connected with the draft tube by a pipe. The clearance between the runner and casing is kept very small and leakage is prevented by labyrinth joints. A small thrust bearing is generally installed to cope with any unbalanced end thrust.

It will be observed from Fig. 10 that the spiral-cased Francis turbine is a very compact unit and compares very favourably in this respect with the Pelton wheel. In its modern form the high-head Francis is a close rival to the Pelton unit. A decade ago 400 ft. was considered a high head for a reaction turbine, but heads of over 500 ft. are now becoming quite common and units operating under 800 ft. have been successfully installed. The reason for the development of the Francis turbine for high heads is due to the modern tendency of larger capacity per unit, coupled with maximum permissible speed to reduce the cost of the generator. This fact is easily appreciated if reference is made to the conditions of the specific speed, which is a governing factor for the type of turbine employed. The whole question of turbine design, in fact, has of late turned on the matter of specific speed. The lowest limit for employment of a Francis turbine with a commercial efficiency corresponds to a specific speed of approximately 11. On the other hand the maximum specific speed for a single-jet Pelton wheel is approximately 5. This reveals the existence of a gap or unfilled sphere corresponding to specific speeds from 5 to 11, under which conditions neither a Francis turbine nor a single-jet Pelton unit can be satisfactorily employed. The only alternative is a double-jet Pelton. Peltons with two jets are, for various reasons, not always satisfactory. The present tendency, however, of increasing the capacity together with a higher actual speed would correspondingly increase the specific speed and bring it within the limits of the Francis turbine where previously a Pelton would only be used. Thus it is that Francis turbines are now available for a very wide range of head. The early troubles with erosion of the runner at high velocities have been overcome, and by securing proper acceleration of the water

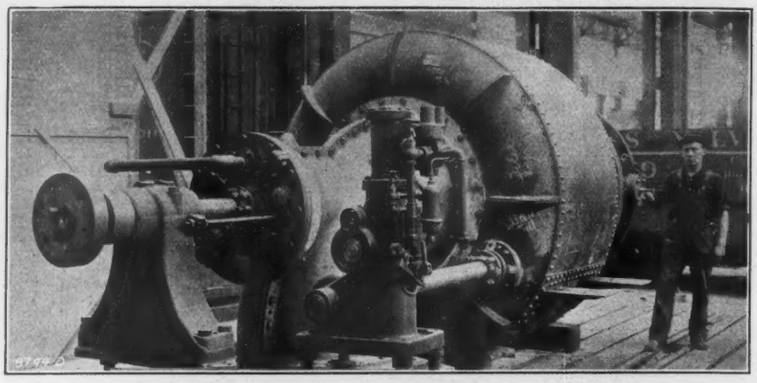


FIG. 4. 250-H.P. SINGLE FRANCIS TURBINE; GOVERNOR END.

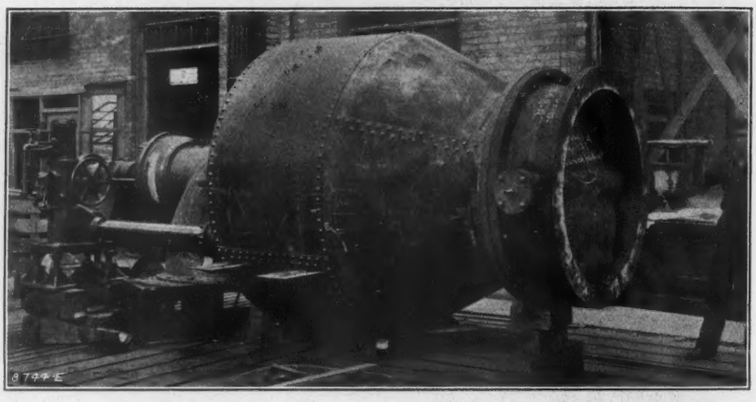


FIG. 5. 250-H.P. SINGLE FRANCIS TURBINE; PENSTOCK END.

Fig.6.

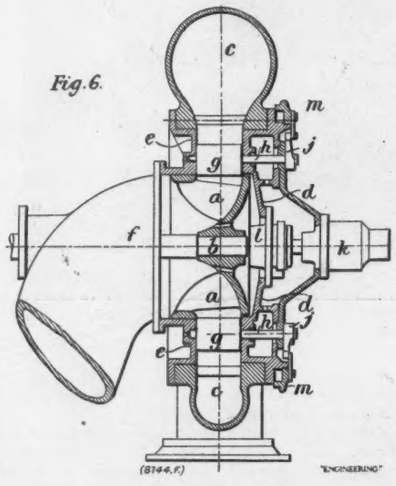


Fig.7.

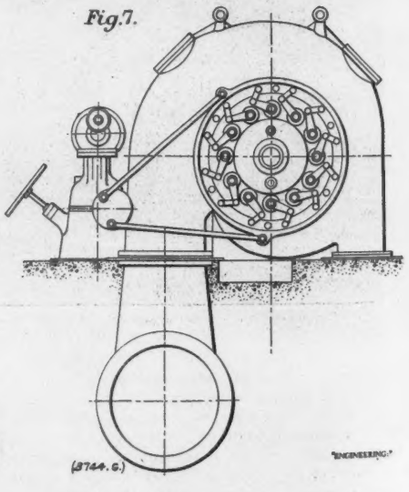
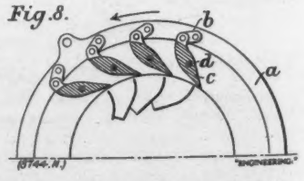


Fig.8.



SMALL HYDRO-ELECTRIC UNITS.

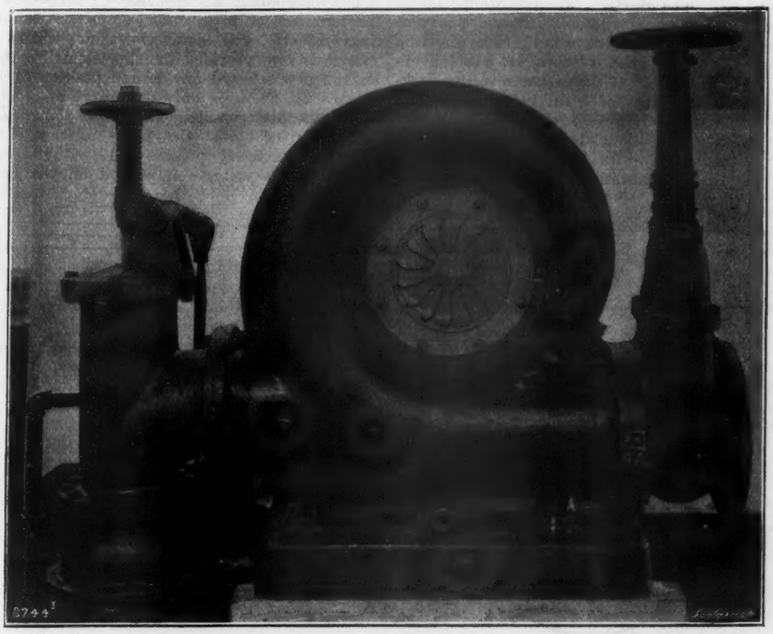


FIG. 9. FRANCIS TURBINE IN SPIRAL CASE.

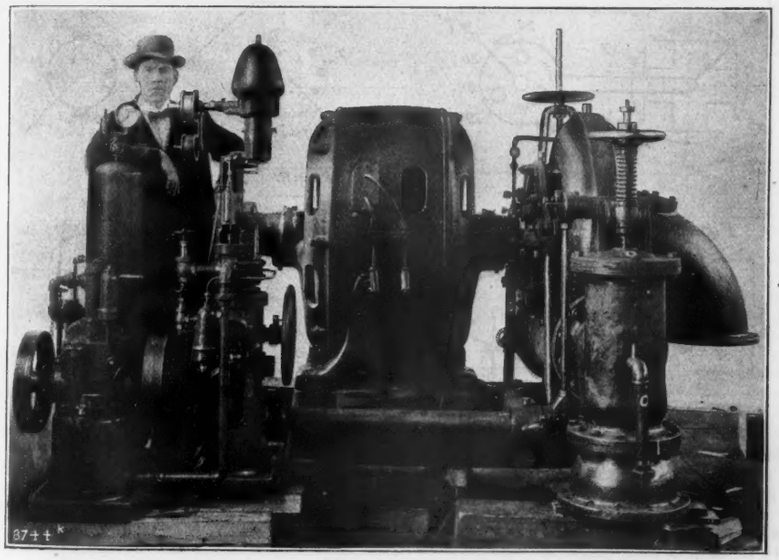


FIG. 10. FRANCIS TURBO-ELECTRIC SET.

through the turbine, higher efficiency has been obtained, rendering the Francis machine an attractive proposition for high heads, nothwithstanding arguments put forward against it by exponents of the Pelton design.

(To be continued.)

DATA ON TWIST DRILLS.—We have received from Messrs. Edgar Allen and Co., Limited, of Imperial Steel Works, Sheffield, a useful pamphlet entitled "Drill Data." In this, references are made not only to the processes of manufacture of the drills produced by the company, but many valuable hints are given on grinding twist drills, lip clearances, rake angles, and speeds and feeds. The causes of failure through lack of care in treatment and usage are dealt with in a simple and concise way which will be of great service to those in charge of drilling, while the tables of data will keep the user right on questions of cutting speeds.

A NEW SEPARATELY EXCITED SYNCHRONOUS INDUCTION MOTOR.

By VAL A. FYNN, M.I.E.E., Fel. A.I.E.E.

(Continued from page 217.)

The New Motor.—One form of the new separately excited polyphase synchronous induction motor, together with its exciter, is diagrammatically shown in Fig. 5, on page 282, which represents a two-pole machine. These motors are preferably built without defined polar projections, but such are shown in most of the figures for convenience in diagrammatic representation. The exciter is mounted on the same shaft as the secondary of the motor, and, because of this, it has the same number of poles as the motor. In practice the exciter will usually have less poles than the motor and will be positively driven from the motor shaft at a correspondingly higher speed.

The motor of Fig. 5 comprises a primary three-phase winding 5, of any desired type, located on the stationary member or stator of the machine and connected to the three-phase supply 2, 3, 4 through the adjustable ratio transformers 60, 61, 62. The two-pole rotor is provided with a two-phase winding, the elements 9 and 10 of which are displaced by 90 electrical degrees, and in consequence there are shown four polar projections on the rotor, diametrically opposed projections carrying parts of the same element of the polyphase rotor winding. The element or phase 9 is connected to the slip-rings 15, 16, with which co-operate stationary brushes 17, 18. The phase 10 is connected to the slip-rings 16, 12, with which co-operate the stationary brushes 17, 13. The slip-rings are carried by the shaft 6. The rotor further carries another winding, preferably of the poly-axially closed type, in the form of a squirrel cage 8. Mounted on the shaft of the synchronous induction motor is an exciter, the revolving member of which carries a winding 19 adapted to be connected to the supply 2, 3, 4 by means of the slip-rings 20, 21, 22, and stationary brushes co-operating with same, and also connected to a commutator with which co-operate the brushes 24, 26 suitably insulated and held in the movable brush support 27, the position of which can be conveniently altered by means of the handle 28. In the figure, the commutator connected to the winding 19 is not shown, and it is assumed that the brushes rest directly on the winding 19, thus eliminating all uncertainty as to their position relatively to the winding. The stationary member co-operating with the rotor of the exciter is laminated but is not shown. The brushes 24 and 26 are connected to the slip-rings 15, 16 with the interposition of the adjustable resistance 34. Brush 24 is also connected to slip-ring 12 with the interposition of the adjustable resistance 33. The slip-rings 15, 16 are shunted by means of the adjustable resistance 35 and the slip-rings 12, 16 by means of the adjustable resistance 36. The winding 19 on the revolving member of the exciter is connected to the supply with the interposition of a phase regulator, the primary 37 of which is stationary and connected to the mains 2, 3, 4, while its secondary 38 can be rotated within the primary by means of the handle 39, thus causing the phase of the polyphase voltages impressed on the sliprings 20, 21, 22 to assume any desired relation with respect to the phase of the line voltages.

The motor shown in Fig. 5, which will be referred to as motor Form 3, can be started, synchronised and operated in different ways according to the results it is desired to secure. Let it first be assumed that the secondary winding 10 on the rotor of the motor, the slipring 12 and the resistances 33 and 36 are omitted. The motor can be started in some well-known way as an induction motor, particularly if the rotor is built without polar projections and carries a polyphase winding located and distributed as is usual in induction motors. The squirrel cage 8 can do duty as a secondary, and the transformers 60, 61, 62 can be used to lower the terminal voltage at starting. During the early stages, the circuit of the rotor winding 9 can either be closed over the resistance 35 or over a suitably high resistance 34 and the brushes 24, 26 of the exciter, thereby protecting the commutator of the exciter from the heavy starting currents. Under these conditions the motor will run up to a nearly synchronous speed. At this stage, the resistance 35 can be cut out if it is in use, and the resistance 34 can be reduced to its synchronising value. If this value differs from that which this resistance must have in normal synchronous operation, then it is changed to the latter value after synchronisation.

The exciter 19, being supplied with line-frequency currents over its slip-rings 20, 21, 22, a revolving flux f' is produced by 19, and the connections are such that this flux is caused to revolve oppositely to the direction of rotation of 19, which is determined by that of the rotor 7 of the motor. When 19 revolves synchronously, f' is stationary with respect to the stator of the exciter. The frequency of the brush voltage will then always be proportional to the slip of the motor, becoming zero at synchronism, at which speed the exciter supplies a unidirectional voltage. The amplitude of the alternating brush voltage depends only on the magnitude

of the polyphase voltages impressed on the slip-rings of the exciter, and can be regulated, if necessary, by means of transformers interposed between the slip-rings and the source of supply. For a given voltage at the exciter slip-rings, the amplitude of the alternating brush voltage is equal to the maximum obtainable value of the unidirectional brush voltage. The actual value of the unidirectional voltage depends on the magnitude of the polyphase voltages impressed on the exciter slip-rings and on the position of the brushes with reference to the axis of the unidirectional magnetisation f' of the exciter. The phase of the alternating brush voltage at sub-synchronous speeds, or the magnitude of the unidirectional brush voltage at synchronism, can be changed (1) by displacing the brushes 24, 26; (2) by changing the points of connection of the slip-rings to the exciter winding 19; (3) by displacing the armature as a whole with respect to the shaft 6; (4) by changing the phase of the voltages impressed on the exciter slip-rings. In Fig. 5, the phase of this voltage is changed by means of the induction regulator 37, 38, but in practice this regulator is not used, and the proper phase relation is secured once for all by keeping the armature 19 in proper position on the shaft 6. In the figure, the phase regulator is used instead in order to facilitate the description.

At sub-synchronous motor speeds, the exciter also runs sub-synchronously, and the brush voltage then alternates with slip frequency, sending a current into the secondary winding 9 on the motor, which increases as the slip frequency diminishes, producing secondary ampere-turns which co-operate with the synchronously revolving flux F′ of the motor to produce a synchronising torque. Because the winding 9 is in inductive relation to the primary 5 of the motor, it is cut by the synchronously revolving motor flux and a voltage is generated in 9, which, when the circuit of this winding is closed, is responsible for an induction-motor-torque-producing current in this winding. This *generated* current is superposed on the synchronising-torque-producing current *conduced* into 9. The generated current decreases with decreasing slip frequency, becoming zero at synchronism, and cannot be, and is not, considered as contributing to the synchronising torque. The conduced current increases with decreasing slip frequency and maintains its magnitude when it becomes unidirectional at synchronism.

The question is: how is the phase of the brush, or synchronising, voltage to be chosen in order to secure a synchronising torque of the most suitable configuration? With the arrangement shown in Fig. 5 it is possible to secure almost anything in the way of a synchronising torque between one of double-slip frequency with equal positive and negative maxima and a strictly unidirectional, but pulsating, torque. The latter is the best to be had with the arrangement shown, but a substantially unidirectional torque is quite sufficient for all practical purposes and more convenient in some respects.

In order to show how the phase of the synchronising voltage is to be selected or adjusted, and just how the synchronising torque is produced, reference will be made to Figs. 6 to 10 inclusive. In Fig. 6 is shown the revolving secondary member 7 of the motor of Fig. 5 and the revolving primary 19 of the exciter, both keyed to the same shaft 6 and therefore both revolving in the same direction. The secondary 7 has four polar projections or four large slots and is laminated throughout. The polar projections are spaced by half a pole pitch, and P, in Fig. 6, measures the pole pitch of this two-pole motor. The brushes co-operating with the exciter winding 19 are located at random. If the primary 5 of the motor produces a synchronously revolving flux F′, which revolves in a clockwise direction, then the rotor 7, starting as the secondary of an induction motor, will revolve in the same direction and will cause the exciter 19 also to revolve clockwise. But the exciter 19 is to provide a unidirectional exciting voltage at synchronism, and, for this reason, the winding 19 must, through its slip-rings 20, 21, 22, be connected to the mains 2, 3, 4 in such a way that, with 19 at rest, the revolving flux f' produced by 19 will revolve counter-clockwise. Under these conditions, this flux f' will become stationary in space when the exciter revolves synchronously in a clockwise direction. After the machine has reached as high a speed as the induction-motor torque can produce, the conditions are as follows:—F′ revolves synchronously and clockwise in space. The rotor 7 revolves in the same direction but at a slower rate; *i.e.* it "slips" to a certain extent. The winding 19 of the exciter revolves clockwise at the same speed as 7, and the revolving flux f' revolves counter-clockwise at slip speed. In order to secure a unidirectional torque between F′ and the conduced ampere-turns in 9, it is clearly necessary for the synchronising brush voltage to be zero when the axis of F′ coincides with the axis of 9, so as to secure its reversal when that component of F′ which is perpendicular to the axis of 9 reverses its direction with respect to the said axis. This condition can be readily brought about, for instance, with the help of some simple measurements on the finished machine.

Fig. 5.

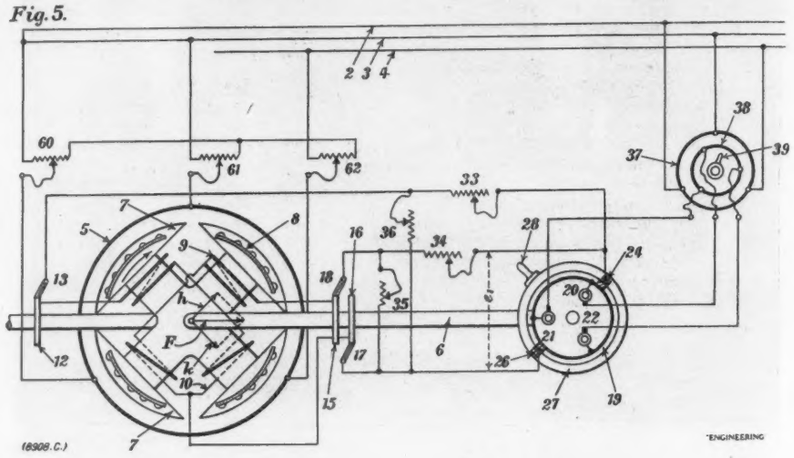


Fig. 6.

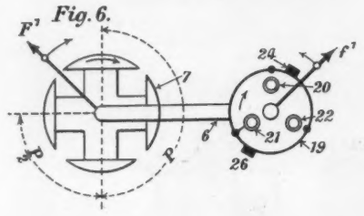


Fig. 8.

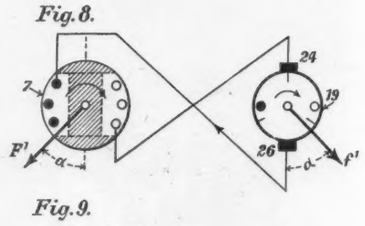


Fig. 9.

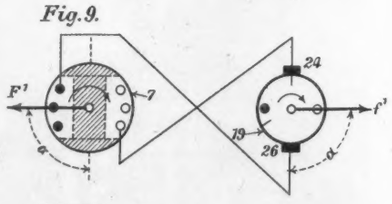


Fig. 7.

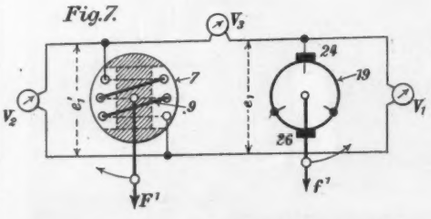
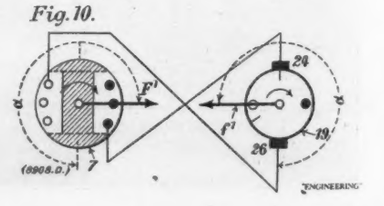


Fig. 10.



Turning to Fig. 7, let it be assumed that the motor member 7 carries only a single winding 9 and that this winding is located in the slots shown in Fig. 7, and is placed close to the periphery of a secondary member 7 without defined polar projections such as would preferably be used in practice. The corresponding position of a secondary member with defined polar projections is indicated by dotted lines, and this form of secondary member is lightly shaded to distinguish it from the rotor form. In the following Figs. 8, 9 and 10 the actual winding 9 is not shown, but the direction of the current in the rotor slots which accommodate this winding is indicated, the circles denoting an upward current and the dots or full circles a downward current.

With the motor running as an induction machine at nearly synchronous speed, the revolving flux F′ cuts the winding 9 at slip frequency and the conditions are the same as if this winding stood still and F′ revolved at slip frequency. When the axis of F′ coincides with the axis of 9, as shown in Fig. 7, then the voltage e'_1 generated in 9 by F′ is zero, and very near synchronism, a voltmeter V_2 connected to the terminals of 9 (in other words, to the slip-rings 15, 16), will distinctly show when this voltage is zero provided the slip is small enough. Having now selected any desired position for the brushes 24, 26, it is only necessary, in order to satisfy the first condition laid down above, so to manipulate or adjust the phase relation of the polyphase voltages impressed on 19, with respect to the polyphase voltages impressed on the motor primary 5, as to cause the brush voltage e_1, measured by the voltmeter V_1, to become zero substantially at the same time as e'_1 measured by V_2 is zero. The brush voltage e_1 is zero whenever the axis of f' coincides with the brush axis. In Fig. 5 the adjustment of the phases of the voltages impressed on 19 can be carried out most conveniently by means of the phase changer 37, 38. A voltmeter V_3 in series with the brushes 24, 26 and the winding 9 will read zero when V_1 and V_2 read zero. At any other instant, V_3 will read the arithmetical sum or difference of V_1 and V_2 and the next question is: should e_1 be of same direction as or opposed to e'_1? The connections must be such that e_1 is of same direction as e'_1 and V_3 must show the arithmetical sum of the readings V_1 and V_2.

To establish the correctness of this conclusion, assume that the winding 9, of Fig. 7, is short-circuited, and that F′ revolves with respect to it at slip frequency. Then it is known that the voltage e'_1

generated in 9 when cut by F′, which voltage we have just caused to pass through zero when e_1 was passing through zero, is going to produce a current in 9, this current co-operating with F′ to produce a positive torque. In fact, this is just the way in which the torque is produced in a standard polyphase induction motor, and the only reason why this torque cannot synchronise the motor in which it is produced is that the magnitude of the current, and therefore of the torque depends on the slip, diminishes as this slip diminishes and becomes zero at synchronism. This consideration clearly determines the direction which the brush voltage should have. Since it is to produce a positive torque, it will certainly do this if it is of the same phase and direction as the voltage generated in 9 near synchronism by the synchronous rotation of F′. Under these conditions, the brush voltage, the maximum amplitude of which is independent of the slip, will continue to force through the secondary of the motor that current which the secondary voltage generated by F′ would have forced through that winding if it had been possible to maintain the secondary voltage e'_1 as synchronism was approached. To secure a unidirectional synchronising torque, the adjustments must be so made that as long as the brush or synchronising voltage e_1 is an alternating one, it substantially coincides as to phase and direction with the voltage e'_1 generated by F′ at nearly synchronous speeds in the secondary on which it is impressed. That these deductions are correct can also be shown by reference to Figs. 8, 9 and 10.

Having set the phase regulator 37, 38 so as to cause the brush voltage e_1 to pass through zero when the voltage e'_1 generated in 9 by F′ also passes through zero, and having connected the brushes 24, 26 to the terminals of 9 so that, in so far as 9 is concerned, e_1 is of the same direction as e'_1, let it be further assumed that, as in Fig. 8, the brush axis and the axis of 9 are vertical. Starting to count time from the instant when both fluxes F′ and f' are in the vertical and directed downwardly, after each has travelled through an angle α of about 45 deg. the voltage e_1 will be directed in 19, as shown by the dot and circle within the circle representing 19, and will force a current through 9 distributed as shown in 7 of Fig. 8. The direction of e_1 is determined by the fact that f' crosses the brush line 24, 26 from left to right and by the direction of rotation of 19, which is clockwise. Remembering that F′ is generated by the primary winding 5 of the motor, it will be seen that in the position which F′ occupies in Fig. 8 it will thread the rotor 7 from right to left and in so doing will produce, with the current distribution shown, a clockwise or positive torque. On the assumption of sinusoidal flux distribution and sinusoidal current and voltage waves, the voltage e_1 will at all times be proportional to sin α, and that component of F′ which is at right angles to the axis of 9, and is alone effective in producing torque with 9, will also be at all times proportional to sin α, with the result that the torque produced will be proportional to $\sin^2 \alpha$ provided the directions here given are followed. In Fig. 9, each of the fluxes F′ and f' has travelled through 90 degrees. The brush voltage is a maximum and all of F′ is effective so far as producing torque with the ampere-turns in 9 is concerned. The synchronising torque T_s is a maximum. After a further travel through 90 deg., the brush voltage becomes zero and the torque is zero. As f' sweeps past the vertical, the brush voltage is reversed, as shown in Fig. 10, which depicts the conditions of maximum reversed brush voltage. This, of course, reverses the current through 9, but F is also reversed, with the result that the torque T_s does not change its direction and remains positive.

The variation of the brush voltage e_1 and the corresponding variations of the torque T_s produced by the synchronising voltage collected by the brushes 24, 25 and conductively impressed on the secondary 9 of the synchronous induction motor, are both shown in Fig. 11. The time during which each positive torque impulse lasts is $\frac{1}{2n_s}$, where n_s is the slip frequency, and is equal to the time required for the brush voltage to go through half a cycle.

But the correlation of parts and arrangement of circuits shown in Fig. 5 is also capable of being used to impart a desirable synchronous operating characteristic to a separately-excited synchronous induction motor. What is needed in order to cause the machine to operate with an acceptable power factor and, what is more important, without drawing an excessive leading current component at any stage of its synchronous operation, is to provide means for decreasing the unidirectional ampere-turns on the secondary with decreasing load. This is achieved in the new motor by causing, with changing motor load, a relative movement between the brush axis of the exciter and the axis of the unidirectional magnetisation f' produced in the exciter by the polyphase currents fed into it. To this end, the well-known inherent property of any synchronous motor is utilised by virtue of which its secondary member changes, with changing load, its position with relation to the axis of the resultant of the polyphase voltages impressed on the primary. The secondary member is the one which carries the unidirectional exciting and neutralising ampere-turns and the axis of these ampere-turns usually follows exactly any change in the position of the secondary member.

When the primary is stationary, the axis of the resultant of the polyphase voltages impressed on the primary, as well as the axis of the unidirectional ampere-turns on the secondary, revolve synchronously in normal operation. As long as the load and the unidirectional voltage are not changed, the relative position of these synchronously-revolving axes is not changed. When the load is increased, the secondary member momentarily decelerates but immediately continues its synchronous rate of progress in a more retarded position with relation to the axis of the resultant terminal voltage. The opposite effect is produced upon a reduction in load; the secondary then accelerates to a less retarded position. Similarly, a decrease in the magnitude of the unidirectional voltage impressed on the secondary causes an increased space displacement and an increase of that voltage causes a decreased displacement between the axes in question. The vector diagram of Fig. 12 is a concrete example of how this displacement changes in the case of a motor in which the unidirectional exciting voltage varies from 45 at no load to 104 at nearly maximum load. The corresponding primary currents are $i_1 = 16$ amperes, leading the terminal voltage E_t by 73 deg. at no load, and $i_2 = 95$ amperes in phase with E_t at nearly maximum load. R_1 and R_2 are the resultant magnetisations at no load and at unity power factor, F_1 and F_2 the corresponding unidirectional magnetisations. The resultant magnetisation R prevailing in synchronous operation replaces the synchronously-revolving magnetisation F′ present at non-synchronous speeds. It is seen that the displacement between E_t and F varies from 96 deg. to 165 deg. This displacement is mechanically transmitted to the exciter by rigidly coupling its armature to the secondary of the motor, and it only remains to utilise this movement properly for the purpose in view.

When the secondary of the motor accelerates or decelerates momentarily in the course of its synchronous rotation and in response to a change in load or in excitation or in both, the periodical space relation between the stationary brush axis and the points at which the slip rings are connected to the exciter winding 19 is changed. The result is exactly the same as if these points of connection had been moved along the winding 19, or as if the phase of the polyphase voltages impressed on the exciter sliprings had been changed. But it has already been explained that, with the exciter-brush axis stationary, a change in the phase of the voltages impressed on the exciter sliprings, or any corresponding change, brings about a change in the position of the axis f' of the flux produced by the polyphase currents fed into the exciter with relation to the brush axis. Any such change means a change in the magnitude of the unidirectional brush voltage. To secure a brush voltage which will rise with increasing load, it is necessary that at no load the axis of the exciter brushes should be displaced from the axis of f' by an angle d smaller than 90 deg., and that the displacement of f', caused by the deceleration of the secondary of the motor, should increase d, thus increasing the effective component of f' in so far as the exciter brush axis is concerned.

The displacement of F with changing load has been referred to the resultant E_t of the polyphase voltages impressed on the motor primary; it could just as well have been referred to R or even to F′, which is replaced by R when the motor passes from sub-synchronism to synchronism. Both R and F′ revolve synchronously with E_t.

(To be continued.)

Fig. 11.

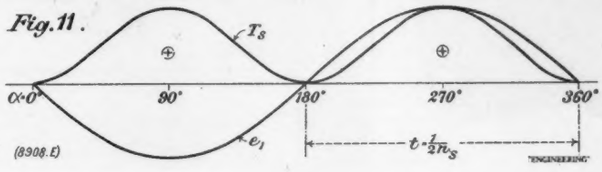
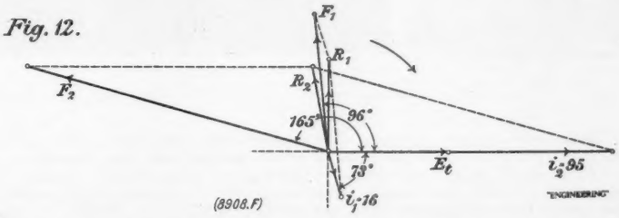


Fig. 12.



THE DEVELOPMENT OF MADAGASCAR.

M. MARCEL OLIVIER, the Governor-General of Madagascar, has recently reviewed the results of French administration in the colony, and of the tasks which still confront it. The French Government has embarked upon a policy according to which all problems concerning agricultural development and settlement are, apparently, to be dealt with by the provincial governments and the local delegations.

The exports from the colony show a remarkable increase during the last ten years. The figures for the four principal commodities are really striking.

	1913. Tons.	1923. Tons.
Rice	10,591	49,387
Tapioca	21,435	27,581
Dried vegetables	8,010	16,219
Graphite	6,466	10,599

Since the colony was first developed, 1,382,440 hectares have been given out in concessions to French citizens, foreigners, and strangers; and, at the present moment the colonial administration has 10,000 applications to deal with. In this matter, the Governor-General admits that the government is faced with grave difficulties: "due, more particularly, to the lack of topographical surveyors, who are so difficult to find since France is under the sad necessity of making a new cadastral survey of her own territory." Topographical surveys are apparently urgently needed in the colony to settle the complicated disputes about property rights, which are continually arising between the native owners and the settlers and concessionaires. The Governor-General thus describes the agricultural policy of his administration: (i) To set up "agricultural stations," each with its own balance sheet, and working under a *conseil d'administration*, on which the native work erswill be represented. These agricultural stations will specialise in the cultivation

FRICTION STARTING GEAR FOR VERTICAL GAS ENGINES.

CONSTRUCTED BY THE NATIONAL GAS ENGINE COMPANY, LIMITED, ENGINEERS, ASHTON-UNDER-LYNE.

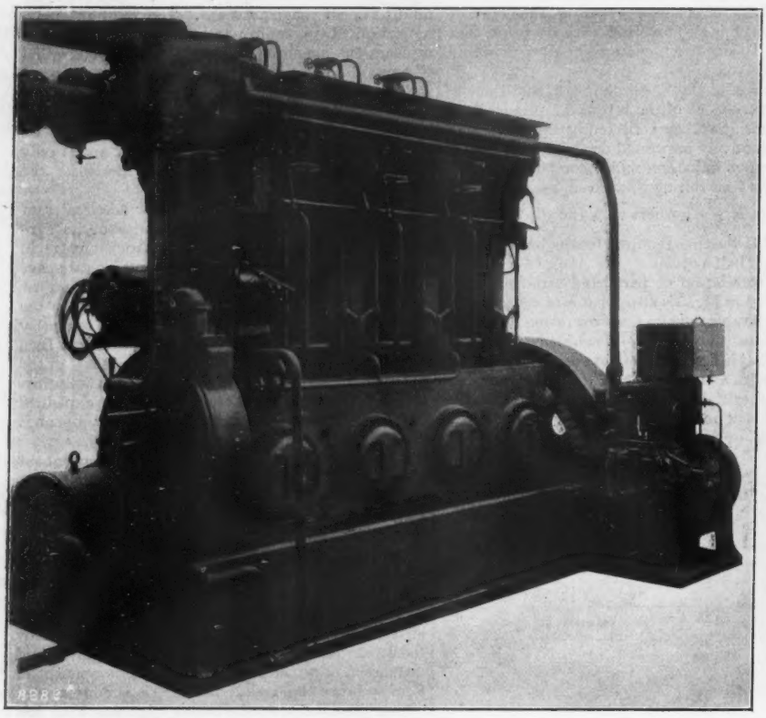


FIG. 1.

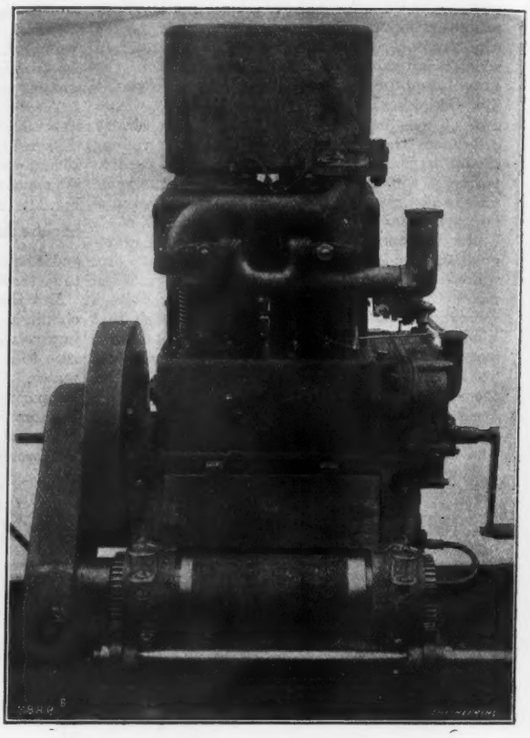


FIG. 2.

of cotton, rice and vanilla. (ii) To spend as much money as can be spared upon agricultural propaganda amongst the native cultivators. (iii) To set up agricultural schools. (iv) To found agricultural savings banks, similar to the *caisses d'épargne* in France, and to spread the use of them by means of existing native communal organisations. In addition to this, Monsieur Olivier is about to set up special committees of experts, to study the problem of irrigating certain delta zones, and using them for the intensive cultivation of rice, sugar-cane and cotton. He does not specifically mention these zones; but he is obviously thinking of the very large alluvial deltas in the Majunga and Ambohibe districts.

The railway development of the colony must, for the moment be limited to constructing an electric railway from Mananara (on the east coast) into the cultivated districts of the Betsileo province, at a cost of sixty million francs, including the charges for developing the harbour facilities at Mananara. The impetus which these railways give to colonial enterprize may be seen from the traffic figures of the Tamatave railway, viz.: 1921, 8,923,866 km. tons; 1922, 13,571,681 km. tons; 1923, 27,377,073 km. tons; 1924, 46,000,000 km. tons (estimated). After the railway development which Monsieur Olivier has marked as *de premier urgence*, he contemplates building electric railways between Antsirabe and Fianarantsoa—a north and south line through the centre of the Betsileo province; and Antsohiby and Befandriana—an E.N.E. W.N.W. running line in the north western part of the colony. The total cost of all the projects he has in mind will be 120,000,000 francs. The administration is, indeed, mainly occupied with the question of developing communications: 3,500,000 francs out of the present budget are devoted to building roads to connect Tulear and Majunga to the high plateaus behind them. In conclusion the governor-general lays great emphasis on the importance of developing wireless stations to connect up with the mother country and the other French colonies, and so "put an end to the costly and dangerous dependence of Madagascar upon foreign cables." The administration has, up to date done everything in its power to develop the wireless communications of the colony. Stations exist at Majunga, Grand Comoro, and Saint Marie: during the coming year the big station, connecting Madagascar to Reunion and French equatorial Africa will be installed at Tananarivo. A word of comment may perhaps be added upon the military significance of the chain of wireless stations by means of which France wishes to maintain communication with her colonies. The German wireless system was not complete when war broke out, and it is very striking to read, from the German staff history how completely isolated the German colonies were, soon after war began. The French government's admitted anxiety to set up a chain of wireless stations, sufficiently numerous and powerful to keep the central government in constant communication with the colonies, is, therefore, well founded. On the other hand, it should be remembered that no establishment or installation is more vulnerable than a high-power wireless station. If near the sea it is a target for bombarding cruisers; if further inland, it is open to raids by small landing forces. There seems no way of avoiding the conclusion that, if these colonial wireless stations are to serve their military purposes they will have to be placed as far inland as possible, that is two or three days march from the sea. If this is impossible, they will certainly have to be protected by fortified posts. At the present moment the military implications of wireless stations in outlying colonies seem to be little thought of; so that it is as well to draw attention to them.

FRICTION STARTING GEAR FOR NATIONAL VERTICAL GAS ENGINES.

IN connection with their vertical gas engines of from 90 to 270 brake horse-power, the National Gas Engine Company, Limited, of Ashton-under-Lyne, utilise a friction starting gear of unusual type. We illustrate this in Figs. 1 to 11 herewith. A general view of the arrangement in position on an engine is given in Figs. 1, 3, 4 and 5, and it will be seen from these figures that it consists essentially of a small auxiliary engine which rotates the main engine flywheel through the medium of a friction pulley.

The auxiliary engine is of the two-cylinder vertical type running on petrol. The cylinders, which form separate castings, are water-cooled, a supply of water sufficient for the short time that the engine is running being contained in a small tank mounted on the cylinder heads. The engine, which will develop 20 brake horse-power at 750 r.p.m., generally follows conventional automobile practice, the crankcase being totally enclosed with pump lubrication to the bearings. Ignition is by high-tension magneto, and a governor is provided to prevent racing when the engine is running light.

A silent chain drive is taken from the engine crankshaft to a shaft carrying a friction pinion. This pinion can be brought into engagement with the smooth surface of the main engine flywheel periphery, causing the latter to rotate at a speed sufficient to charge the main engine cylinders and effect ignition Details of the auxiliary drive can be seen in Figs. 2, 5 10, and 11. The friction pinion is built up with Ferodo, and sufficient testimony to the efficiency of the friction drive is given by the fact that the system is in regular use on many of the National gas engine installations and has proved quite successful.

To allow the friction pinion to break contact with the main engine flywheel after the main engine has started, provision is made for throwing the pinion in and out of contact by means of a foot lever. The arrangement is shown in Figs. 10 and 11, from which it will be seen that the spindle carrying the pinion is mounted in two eccentric bushes, having teeth cut on the periphery of one flange of each bush. These teeth engage with toothed quadrants mounted on the operating shaft, so that the act of depressing the foot pedal causes the rotation of the eccentric bushes through about a half revolution. Details of these bushes and quadrants are given in Figs. 6 to 9. The whole gear with engine, stand, striking gear, &c. is mounted on a cast-iron sole plate which is embedded in the floor. This sole plate is fitted with slots and adjusting screws so that the gear can be easily adjusted in relation to the flywheel in the event of wear of the friction pinion.

ELECTROLYSERS FOR THE PRODUCTION OF SODIUM HYPOCHLORITE.

ELECTROLYTIC sodium hypochlorite has been largely used in industry as a powerful bleaching, oxidising, sterilising, and deodorising agent, mainly on account of its effectiveness and low cost, but also because of its non-poisonous and generally harmless character. It is produced by passing a direct current through a solution of common salt in water, hydrogen being given off from

FRICTION STARTING GEAR FOR VERTICAL GAS ENGINES.

CONSTRUCTED BY THE NATIONAL GAS ENGINE COMPANY, LIMITED, ENGINEERS, ASHTON-UNDER-LYNE.

(For Description, see opposite Page.)

Fig. 3.

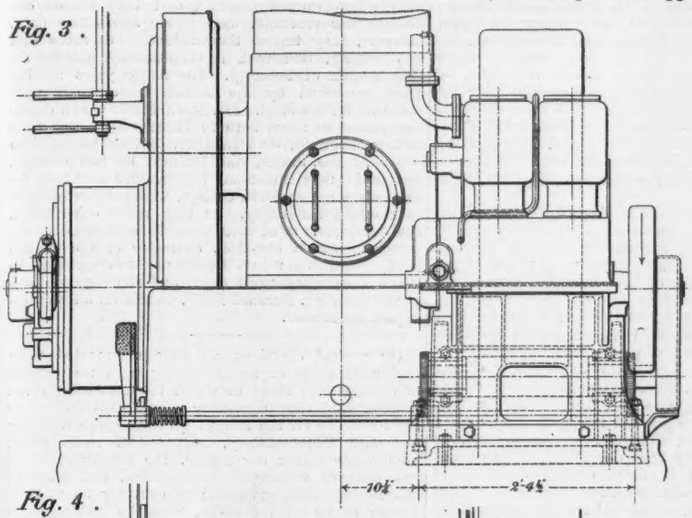


Fig. 5.

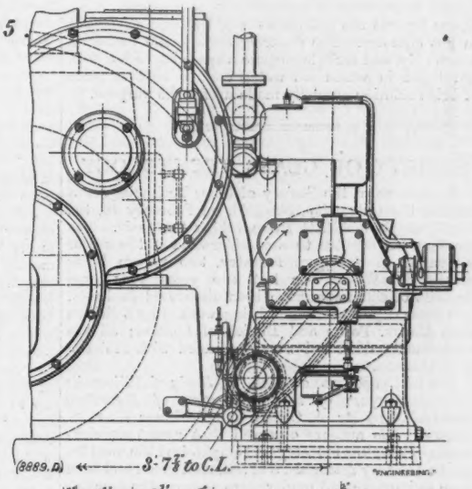


Fig. 4.

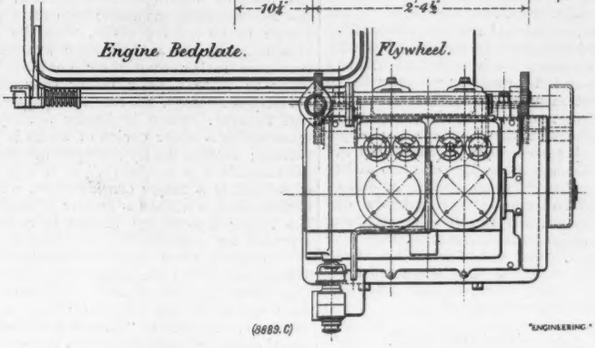


Fig. 6.

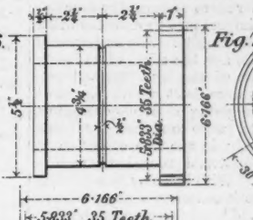


Fig. 7.

Fig. 8.

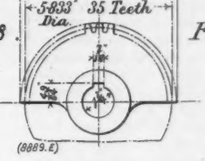


Fig. 9.

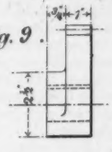


Fig. 10.

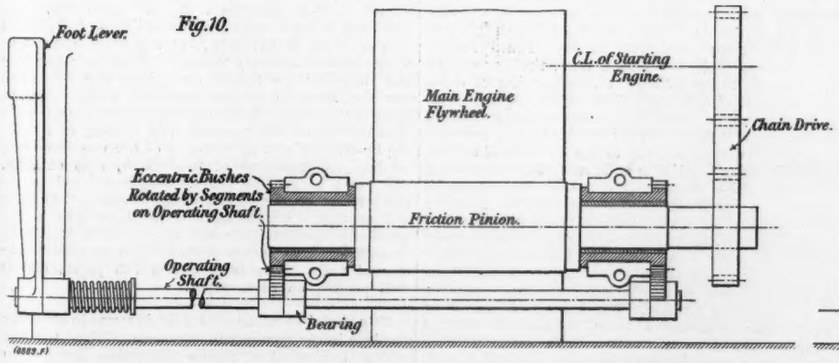
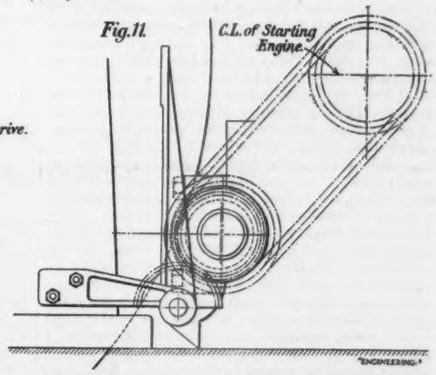


Fig. 11.



the negative electrode and sodium hypochlorite being formed in the solution. The latter can be used for bleaching textiles and paper pulp, the chlorination of wool, and the purification of water, as well as for sanitary purposes as a disinfectant and as an antiseptic in surgical work and in other applications. The electrolytic hypochlorite has the important advantage, in comparison with bleaching powder, that it is stable even under tropical conditions, whereas bleaching powder steadily decomposes and loses its strength from the time it is made to the time it is used. The resulting uncertainty as to its exact composition is thus a drawback to the use of bleaching powder, and a further disadvantage arises from the tendency of its calcium content (it contains hypochlorite of lime) to form insoluble compounds which are particularly objectionable in bleaching textiles.

Messrs. Mather and Platt, Limited, Park Works, Manchester, have given considerable attention to the design and construction of plant for the production of electrolytic sodium hypochlorite, and a large electrolyser for this purpose was illustrated and described in our issue of June 13 last, on page 780. We have recently received from the firm some particulars of smaller electrolysers, which are made in a range of sizes, capable of producing stable sodium-hypochlorite solution in quantities suited to the requirements of municipal engineers, medical officers of health, hospitals, tea and rubber estates, laundries, bleach works, &c., as well as for water purification, &c. The smallest electrolyser made consists of an ebonite cell which stands in a glass container and requires a current of 5 amperes at from 10 volts to 12 volts; a number of cells can, of course, be connected in series in accordance with the supply voltage. In this cell the electrodes are of platinum, and it is possible to obtain from it hypochlorite solution in which the concentration of available chlorine is as high as 5 per cent. Solutions in which the available chlorine concentration is higher than 2 per cent., however, are rarely required. In practice, the glass container is filled with a 20 per cent. to 30 per cent. solution of brine, the current then being switched on to the cell and adjusted to 5 amperes by a suitable variable resistance. The cell itself contains about a quarter of a gallon of solution, and in a run of four and a-half hours' duration this quantity of sodium-hypochlorite solution, containing 2 per cent. of available chlorine, is produced in each cell. Smaller quantities of hypochlorite solution of higher concentration can be obtained by modifying the strength of the brine and the length of the run. Some little attention is necessary at the commencement and end of the run, but for the remainder of the time the apparatus can be left alone, the cell being designed to provide automatic circulation of the solution, thus preventing local action and overheating.

Larger electrolysers have graphite electrodes in place of platinum, and the electrodes, which are readily renewable, are mounted in a holder of chlorine-resisting vulcanite shaped so as to ensure a rapid and effective circulation of the electrolyte through the cell. Cells of this type are made in four standard sizes, taking 5, 12½, 30, and 60 amperes, respectively. The voltage drop per cell, with graphite electrodes, ranges from 22 to 24 in the smallest size to 47 to 55 in the largest, the output of the former being about one gallon of solution at a strength of 1 per cent. available chlorine after a run of three hours. The 12½-ampere cell produces about 1½ gallons per hour of solution of the strength

just mentioned, and the two larger sizes produce 3½ gallons and 8 gallons per hour, respectively. These outputs, we understand, are conservatively estimated and can easily be maintained under the trying conditions existing in tropical countries, where the electrolysers are especially useful. The particulars given should therefore be of interest to those engineers whose duties include the maintenance of hygienic conditions in hot climates. The electrolysers are also useful on board ship, and for this purpose a special type has been developed in which sea water can be used in place of brine solution specially made up for the purpose.

SOCIETY OF GLASS TECHNOLOGY.

A MEETING of the Society of Glass Technology was held at the University, Sheffield, on February 18, the President, Colonel S. C. Halse, taking the chair. The meeting was devoted to a consideration of the use of sillimanite in the glass industry, two papers being presented. Within the last two years very large deposits of sillimanite have been discovered in India, and these deposits are now being worked by a British firm, Messrs. Pawle and Brelick of London; all the experiments described were conducted with material from this source.

The first paper was entitled "*A Study of Sillimanite for the Purpose of the Preparation of Refractory Materials*," by Mr. A. Cousen and Professor W. E. S. Turner. The authors observed that recent developments in the glass industry had emphasised the need for good refractory materials, and although much had been done to improve and render more uniform the fireclays now employed, it was of importance to examine other material likely to give better results. The authors had made a study of sillimanite, and the effect of variation of grain size and of the use of varying types and proportions of bonding agent were dealt with. The most plastic mixtures, and those giving on fireclay the most stable and resistant pots, were obtained by using sillimanite wholly, or largely, in the fine condition in which the bulk of the material passed through a 100 mesh to the inch sieve. With ball clay as a bonding material, good results were found when a proportion of 15 per cent. to 30 per cent. of bond was employed. The porosity of hand-moulded specimens was inversely proportional to the amount of bonding agent used and, with the addition of 30 per cent. of ball clay, was as low as 22 per cent. Actual melting tests with soda-lime, potash lead and fluoride opal batches gave glasses superior in colour to, and having a lower iron-oxide content than those melted in good fireclay pots. Test slabs, both with 15 per cent. and 30 per cent. of bond, withstood a larger breaking load than fireclay slabs after firing at 1,000 deg. to 1,400 deg., but after heating to 100 deg. or 800 deg. the clay slabs gave superior results. Stourbridge clay gave a less plastic mixture, which produced, on firing to 1,400 deg., a more porous texture than equivalent mixtures in which ball clay was used. The Stourbridge clay mixtures, however, gave promise of producing quite good results when moulded into shape under pressure. Bentonite, a hydrated silicate of aluminium of variable composition, although giving the most plastic mixtures, proved unsatisfactory in practice, and the results obtained did not justify its employment as a bonding agent.

The second paper was entitled "*Some Notes on the Use of Sillimanite as a Glass Works Refractory*," by Mr. F. G. Clark and Mr. W. J. Rees. The authors explained that, for many years, manufacturers had been looking for a refractory material which would not only stand the higher temperatures at which furnaces had been worked in recent years, but would also withstand the action of melting batch and molten glass upon it at those high temperatures. Tests under commercial conditions showed that molten glass had very little attack on articles made of sillimanite and should have very little effect on sieges made of this material. Bricks of various sizes and thicknesses had also been made of a sillimanite mixture and used for filling up the exit flues of furnaces when they had worn too big. It was found that these bricks stood the heat perfectly. The mixture was also used in a damp state for repairing the bad places between the pillars and springers in an old furnace, with excellent results. The best results had been obtained with sillimanite bonded with from 10 per cent. to 25 per cent. of ball clay. A covered pot had been made from 25 per cent. of ball-clay mixture soaked for four weeks before use. This pot was 43 in. high and took 15 days to make. Its cost was greater than that of the ordinary fireclay pot, but longer life in the furnace and freedom from pot stones would compensate for this. The material was also recommended for rings floating in the glass and for bottoms of tank furnaces. Its thermal conductivity was higher than that of fireclay. The authors expressed the opinion that sillimanite was the best refractory material yet known for use in the hottest part of any glass furnace, either in contact, or out of contact, with glass.

ACTION OF IRON ON COPPER AT HIGH TEMPERATURES.

FOUNDRYMEN are aware that copper is liable to deteriorate when it is heated in contact with iron, and they avoid these effects by lining iron vessels, in which copper wire is to be annealed, with copper. According to P. Siebe, of the Osnabrück copper works (*Zeitschrift für Metallkunde*, for January), the effect would appear to be due to a reduction of the cuprous oxide, almost always present in copper, by the hydrogen and carbon monoxide evolved from the hot iron. Siebe could only trace one literature reference on the subject, an observation made by H. C. H. Carpenter, during vacuum-etching tests, when studying the "Effect of Oxidising Gases at Low Pressures on Heated Iron" (see ENGINEERING, May 12, 1922, page 605).

Siebe experimented with electrolytic or refined copper and with a low-carbon steel (about 0·06 C mostly), either piling alternating sheets of the two metals upon one another, or inserting a rod of the one metal into a tube of the other, and heating the whole, carefully excluding the air. He found, by bending tests and the indentation test of Erichsen (in which a round-nosed tool is forced against the sheet and the depth of the cup produced is measured) that the ductility of the copper was decreased, and that of the iron increased, when the two metals were heated up to 600 deg. C. or more, and also that the effect on copper was the more marked the higher the oxygen contents of the copper, whilst there was no deterioration when the copper had been deoxidised. The oxygen content was raised in definite proportions up to 0·28 per cent. In other tests, iron wires were dipped into copper fused in cylindrical moulds. Deoxidised copper then adhered uniformly to the iron; but with oxidised copper the contact was irregular, gas bubbles developing on the wire and preventing contact with the copper. The explanation suggested by Siebe is that the hydrogen and carbon monoxide in the iron reduce the oxides or combine with the oxygen in the copper and form water and carbon dioxide which are not soluble in copper. Carbon monoxide does not diffuse through hot copper, but it penetrates to a certain depth. The reduction observed is probably due chiefly to the hydrogen, but quantitative estimates indicate that the carbon monoxide must also take part in the reduction. The carbon percentage of the iron did not appear to be of importance for these reductions.

NOTES ON NEW BOOKS.

IT is a commonplace of the present-day educationalist that history must be taught as a living subject, illustrated by the lives and deeds of men who have helped mankind on its forward march, and that the time has passed when the learner can be expected to be satisfied with mere lists of dates and accounts of unimportant political intrigues. This modern point of view has wrought great changes in history text-books, but even now it is doubtful if sufficient weight is given to the advance of science and engineering practice in building up the constitution of society which we have lived to see. This omission, however, is probably not altogether the fault of the historians, as neither scientific men nor engineers have, as a rule, shown any very great interest in the history of their own subjects. Recent years have perhaps shown something of a change; the activities of the Newcomen Society in particular are illustrative of an increasing interest. The writing of history on broad lines demands a large amount of detailed compilation which can usually only be made by those who have special facilities in some particular field, and interesting work of this kind has been done by several workers in recent years. An excellent example of such work which could not fail to be of very great value to a student of the history and growth of the steel trade is furnished by a recent book published by Messrs. Thos. Firth and Sons, Ltd., of Sheffield. It has been compiled by Messrs. A. C. Marshall and Herbert Newbould, and is entitled "*The History of Firths* (1842–1918)." The subject of the book is sufficiently indicated by its title. Firths is, of course, a landmark in Sheffield, but it is more than that; it is a landmark in the history of the steel trade of the world, and the story of its beginning and progress forms matter which should certainly be recorded. The firm was founded in 1842 by Mr. Thomas Firth and his two sons, Mark and Thomas. The early days were those of small things, and a copy from the wages book for the week ended July 6, 1844, shows a weekly wage bill of 9*l.* 12*s.* 6*d.*, of which Thomas Firth received 2*l.* 10*s.* and Mark Firth 1*l.* 15*s.* The firm, however, showed great ability and enterprise from the first, and on August 10 of that year they banked 1,003*l.* 7*s.* Thomas Firth, senior, died in 1850, and the chief direction of the firm fell to Mark, a man of quite unusual ability, who in a few years placed his firm in the front rank among steel makers of this or any other country. Until about 1860, the firm was chiefly concerned with the making of crucible cast steel, although in those days manufacturing had not reached the stage of specialisation with which we are familiar, and they turned out many other products. Somewhere about this date, however, they turned their attention to shells and gun forging, and took a commanding position in this branch of industry. For many years all big guns purchased by the British Government were made of Firth's steel. Mr. Mark Firth, whose career had meant so much both to Thomas Firth and Sons and to Sheffield, died in 1880, leaving behind him not only the magnificent business he had created, but very many important benefactions of which we can only mention Firth College, which is now merged in Sheffield University. As with many other firms, the developments of later days have eliminated the personal, almost one-man, character of the control of Firths, but its best traditions have survived to these more complicated days, and the present head of the firm, Mr. Bernard Firth, carries on an uninterrupted succession.

ON several occasions we have commented upon the multiplicity of books dealing with the subject of costing. To those in which the treatment given is such that they constitute a real contribution to the literature on the subject we have given a hearty welcome. Unfortunately, in some of those which have come under our notice, the treatment given has been so superficial in character, and some of the recommendations made so contrary to what is known to be good practice, that the impression is obtained that the authors have written out of their ignorance rather than their knowledge, the desire being to write a book rather than to pass on to industry a message, the result of research, experience, and thought. There is hardly a subject, perhaps, upon which a wider choice of books is possible than costing; there is hardly a subject about which greater discrimination is necessary. It is not that the cost of a book is a major consideration, although to the student this is always a matter of some importance, but rather that things written in a book are often accepted as authoritative or valuable because they are in print, error being disseminated as a result. While the latest book to reach us gives no indication that there is anything new in its teaching, it is free from errors of the kind to which we have made reference. Its title is "*Elements of Cost Accounting*," and it comes from America, from the pen of Anthony B. Manning (McGraw Hill Book Company. London: 6 and 8, Bouverie-street, E.C.4. Price 10*s.* net). The book is based upon lectures delivered to students and, as is to be expected, the subject is treated in a somewhat elementary manner. While various forms and diagrams are shown throughout the book, the aim has been to discuss principles rather than to describe a system. There are chapters on the purchase of material, on the payment and costing of labour, the making up and distribution of the manufacturing burden—oncosts—cost of production, cost of sales, and gross profit and general ledger procedure. To the person who has no knowledge of costing, the book will provide a simple and, as far as it goes, a not unreliable introduction; but, beyond these limits, the treatment given is not sufficiently extensive to be of real value. The book covers 166 pages, and is well printed on good paper.

THE electrical industry of Austria seems to be taking the lead in the recovery of the country from the war which reduced the Austro-Hungarian Empire to the size of a province and severed the arteries, extending from Vienna in all directions, to centres of commerce and industry. That recovery may have something to do with the fact that the "*Elektrische Zugförderung*," by Dr. Ing. E. E. Seefehlner, of Vienna, the first edition of which appeared in 1922, is already before us in its second edition (Berlin: Julius Springer; price 11·45 dols.). The book has some intrinsic merits. The engineer will notice that more attention is paid to railway engineering than is frequently the case in books on electric railway practice. Among the striking features of Dr. Seefehlner's volume are the long bibliography lists at the end of the many sections, the tabular matter, and the three alphabetical indexes, of names, places, and subject-matter. Such assistance is very welcome even in a profusely illustrated book of 659 pages; occasionally the bibliography might have been rendered still more useful by cross-references, but particular devices noticed or illustrated can generally be identified by names or places. The summary of the chief data regarding electric locomotives deals with nearly four hundred designs. The section on rack railways and wire-rope railways, entirely written by Mr. H. H. Peter, of Zürich, is welcome.

But we hardly see why Dr. Seefehlner has added an appendix on applied nomography to his volume. Mention of the fact that he has found nomographic methods very useful would have been sufficient.

While the basic principles underlying smelting operations remain unaltered, methods of manufacture are continually being improved as a result of scientific research and practical experience. Modern metallurgical practice consists not only in obtaining a greater yield and a more regular output of metal than was formerly the case, but also aims at a more stringent elimination of waste and a more efficient utilisation of all by-products. Much progress has been made during the past two decades, and for this reason a new and revised edition of "*Metallurgy*," by E. L. Rhead, M.Sc.Tech., F.I.C., A.I.Mech.E., has been published by Messrs. Longmans, Green and Co., the price being 7*s.* 6*d.* net. The work is described as an elementary text-book, and opens with chapters dealing with the properties of metals, definitions of terms, furnace types, fuels, and refractories. Some good photo-micrographs are included in order to give the student a "sound idea of the importance of metallography in the behaviour and application of metals." In the section devoted to ore-dressing, recent advances in electrostatic concentration and flotation processes are touched upon by the author. About 25 per cent. of the available space deals with the production of iron and steel, and modern improvements in blast-furnace practice are described in detail, this account being particularly well illustrated. The section devoted to open-hearth steel-making has not been modernised to the same extent, tilting furnaces and mixers do not appear to be mentioned at all. Again, the electric steel furnace is only very briefly discussed. The methods used in the production of wrought-iron and "blister" steel are dealt with at some length by the author, there being still a demand for such materials. Moreover, the processes involved are of rather more than historical interest to the student. The chapter on copper is an important one, and is thorough and complete. All modern methods of refining the metal are well set out, and the theoretical side of each process is illustrated by means of chemical equations. A chapter is devoted to each of the following metals: lead, mercury, silver, gold, and tin. The extraction and purification of other metals, such as zinc, antimony, nickel and aluminium, are described more briefly. Lead-smelting is divided into two sections, the one dealing with reaction and the other with reduction processes; the important subject of desilverisation receives some attention. The chapter on tin includes a brief account of the manufacture of tin-plate. While some considerable space is devoted to detailed and well-illustrated descriptions of modern methods of refining the precious metals, the account of the processes employed in the smelting of aluminium and the brief summary of its physical properties are limited to about half a page. The metallurgy of aluminium has made immense strides during the last ten years, and the practical usefulness of the light alloys is now an established fact. It must be allowed, however, that the condensation into the narrow compass of 400 pages of the knowledge available on such a wide and constantly expanding subject as metallurgy is indeed a difficult task, and the author is to be congratulated upon having produced a highly readable book. The language used is clear and concise and the style is pleasant. An appendix giving details of some of the more common alloys is included.

In almost every type of technical industry, terms are used which are either not commonly employed in ordinary speech, or have a special significance attached to them. A difficulty therefore arises, for the usual dictionaries may contain no reference to the special meanings applied to such words. Only through specially prepared works is it possible to obtain a full knowledge of the sense in which these expressions are employed in technical English. A multitude of text-books might have to be studied to obtain the required definitions, and, however regrettable it may be, it must be recognised that many standard works do not contain exact definitions of some of the expressions in common use. The trouble may be overcome if a work specially prepared to give the requisite information is available. Such a work, for one particular branch, is Mr. S. R. Roget's "*A Dictionary of Electrical Terms*," recently published by Sir Isaac Pitman and Sons, Limited, of Parker-street, Kingsway, London, at a price of 7*s.* 6*d.* net. In this compilation is given, in alphabetical order, a collection of the expressions used in the science and application of electricity and magnetism, with definitions which are stated with all that is requisite in accuracy, but in such a way as to avoid redundancy. Only the actual electrical side of technical work is dealt with, and consequently nothing is given which covers the engines or turbines used for the generation of electricity. American expressions, where they differ from the English ones, have been included to extend the usefulness of the book. When purely trade names are so intimately associated with plant as to amount almost to technical terms, they have been included, but otherwise they have been neglected. The work is quite well done, and for anyone who desires information, in limited bulk, of the type the author gives, this small book of 300 pages can be recommended.

Books on nomography are increasing in number. We noticed two in our issues of April 11 and May 2 last, and from one of the most recent contributions to this literature, the "*Lehrbuch der Nomographie*," by H. Schwerdt (Berlin: Julius Springer; 12·90 gold marks, bound), we see that about 300 years ago books of cognate character, though not of the same title and of more restricted scope, were quite common. Following P. Luckey's Nomographie, Mr. Schwerdt traces this method of graphical calculation and tabulation, generally associated with the name of Maurice d'Ocagne, back to Léon Lalanne's "Mémoire sur les Tables Graphiques and la Géométrie Anamorphique" of 1845, and, further, to the astrolabia of the Arabians, first described in a manuscript of the year 959, to the horologium of Regiomantanus (Johannes Müller, died 1476), to Mercator's map projection of 1569, and to other names and instruments. Schwerdt takes his examples from all branches of science and indicates the method of solving about 150 problems. On the good paper of the book the 127 diagrams, though necessarily on a small scale in an octavo volume, come out with remarkable distinctness.

M. Edmond Marcotte has compiled his volume on "*Les Lignites et leur Applications Industrielles*" (Paris: Gauthier-Villars et Cie; price 20 francs) for the benefit of financiers, men in the public service, miners, industrialists and also technical men generally, because France spends annually three milliards of francs on 30,000,000 tons of coal and fuel, utilising only 800,000 tons annually of her own coal resources of 3 or 4 milliards of tons, whilst Germany mines, carbonises, gasifies and briquets 140 million tons. The dedication prepares the reader for a somewhat popular treatment of the subject, and we do not wonder, but regret, that M. Marcotte has not taken the trouble to compile an index, and that there is nothing but a table of contents of 17 lines to indicate to the reader what the book contains. M. Marcotte estimates the lignite deposits of France at 2 milliards of tons. This is done in his fourth chapter, in which he reviews the deposits as known in 1924; he also gives information on actual production. His fifth chapter deals with the Cologne lignite basin on similar lines; his estimates, based on German statistics for the central bed of that district, is $2 \cdot 8 \times 10^9$ tons, but the production has risen from 21,000,000 tons in 1913 to 35,000,000 in 1922. Why M. Marcotte devotes his first three chapters—the third chapter is headed "Géognosie—to the lignite deposits of France and other countries, as averaged in 1860, we do not quite understand. When the author passes to exploitation, drying, carbonisation, gasification and by-product recovery, he is more satisfactory, and a good many recent devices and processes are duly noticed. But it is just there that the want of an index is so much felt. The book, though generally instructive, is not sufficiently comprehensive for systematic study, and will therefore be liable to be underrated. The important chapter on laboratory studies of lignites and on their conversion into hydro-carbons, has been contributed by M. P. Petroff, of Paris, and is well up to date. The financial balance-sheets of some German works, dating from 1889, are not of interest.

COAL DUST IN MINES.—Several recommendations regarding the avoidance of explosions in mines have been embodied in a report dealing with the dangers of coal dust submitted to the United States Department of the Interior by Mr. George S. Rice, chief engineer of the Bureau of Mines. In this report, it is pointed out that stone dust, when distributed through a mine, combines with the coal dust accumulations and forms a non-explosive mixture. If coal dust is allowed to collect underground after stone dust has been applied, a condition quickly arises such that the mixture is once more explosive. One of the principal sources of dust results from operating machines used in undercutting the coal. It is advised that a method of keeping down this dust is to use a water spray on the cutter bar. Further, dust produced when cutting coal should be removed before blasting, in order to prevent the dust being carried away and deposited by the ventilating current. Another prolific source of dust is "sifting," which takes place from leaky cars and is blown by air currents from loaded or empty cars during transit between the working face and the mine opening. Drenching the cars with a spray of water while they are in transit is suggested as an effective and economical measure of prevention. A third cause of dust is the pulverising of pieces of coal which drop from loaded cars to the track.

HEATING BY EXHAUST STEAM.

THE savings that may follow from heating by exhaust steam are admitted more often than they are taken advantage of, and a formidable quantity of coal must be wasted every year in maintaining separate furnaces for heating systems, when the work could be done equally well by exhaust steam without adding appreciably to the furnace loss already incurred. In particular, the exhaust from suitably designed turbines lends itself to such use conveniently and economically, and a good example of the sort of service they can render is given by the installation recently carried out at the Halifax Royal Infirmary by Messrs. Greenwood and Batley, Limited, of Leeds. A plan of the building showing the heating piping is given in Fig. 2, on page 288.

The plant of which the exhaust is used for heating is a 75 b.h.p. steam turbo-alternator of the de Laval simple impulse geared type with an output of 50 kw., a view of which is given in Fig. 1. The turbine is of the firm's standard design, which through its flexible shaft and coupling, runs with the freedom from vibration that has always characterised the de Laval turbines. The only respect in which the present standard design seems to differ from that which is generally known is that the oil cooler used in connection with the forced lubrication is no longer arranged within the bedplate but is placed in any convenient situation outside it; usually across the bedplate, as seen in Fig. 1, to the right of the alternator. The turbine wheel runs at 16,500 r.p.m., which is reduced by single-reduction double-helical gearing to 1,500 r.p.m., the gear wheel being divided into two parts with an intermediate bearing according to the makers' usual practice. The alternator is of the revolving field type with stationary armature, excited by an enclosed ventilated dynamo at the outer end of the alternator and coupled directly to its rotor shaft. The alternator generates 3-phase 50-cycle current at 400 volts, with neutral point brought out for lighting at 230 volts. The current is used for a variety of minor power purposes, such as supplying the motors that drive the mechanical stokers, hoist, laundry machinery, and surgical and general domestic appliances. Up to now only 15 kw. is used in all, falling in daytime to 12 kw., though extensions are in progress by which the load will be raised more nearly to the full capacity of the machine.

The turbine is driven with steam at 80 lb. pressure and 60 deg. F. superheat at the governor valve, and exhausts at a back pressure of 5 lb., though the area of the nozzles is enough for a back pressure of 10 lb., should the services operated by the exhaust need as much. Fig. 2 is a block plan of the premises in which the steam has to be used, indicating the general layout and the run of the main flow and return and the heating circuits. The buildings contain some 1,000,000 cubic feet, of which about half is heated. In accordance with the modern practice of hospital buildings, they are provided liberally with cross ventilation, and an inspection of the plan gives a fair idea of the relatively large amount of heat that is lost through the disposition of the buildings, and has to be made good by the heating arrangements. In addition to heating the buildings, for which about 4,600 sq. ft. of heating surface is provided, and various appliances such as low-pressure sterilisers, the exhaust also serves a 300-gallon Royle's calorifier, which, with steam at 5 lb. pressure, can heat 2,000 gallons of water per hour from 60 deg. to 180 deg. F. In the installation under notice it raises about 40,000 gallons of water per week from 50 deg. F. to 170 deg. F., with steam of which the pressure has fallen to 2 lb. per square inch when it reaches the calorifier. The high-pressure disinfecting plant is served directly from the boiler through a reducing valve, set to deliver steam at 40 lb.

The system by which the steam is distributed to the heating surfaces is suggested in outline in Fig. 2. The motive force for the distribution is provided in the plant itself, which delivers the steam at a pressure of 5 lb. per square inch—the back pressure of the exhaust—and assists the return of the condensate by a vacuum plant, the latter adjusting itself automatically to the requirements of the system. The steam is conveyed by 250 ft. of 6 in. cast-iron piping to the centre of the institution, whence it passes into four 3 in. heating mains extending to the several buildings to be heated, off which mains the local heating circuits are tapped. The return ends of these circuits are controlled by 3 ft. nickel-brass expansion steam traps, preventing the steam from passing into the return until it has been condensed in the heating circuit. The returns are collected into a return main, which leads to the air-tight receiver of a Jennings Hytor vacuum pump near the boiler house and turbine set. This pump serves both to maintain a predetermined vacuum of from 13 to 17 inches of mercury in the receiver and the return mains, under which the condensate is drawn from the return mains to the receiver, and to lift and force the contents of the receiver into a 100-gallon tank some 12 ft. above the receiver. Thence it is forced into the boiler by a motor.

POWER AND HEATING PLANT AT THE ROYAL HALIFAX INFIRMARY.

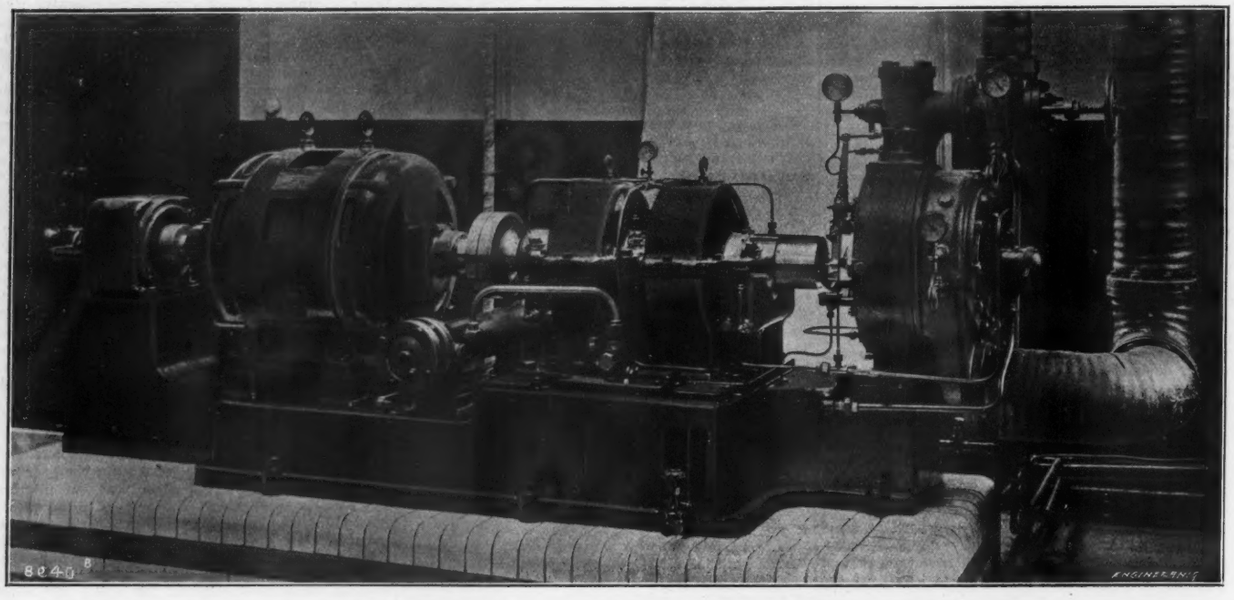


FIG. 1. DE LAVAL TURBO-ALTERNATOR; MESSRS. GREENWOOD AND BATLEY, LIMITED.

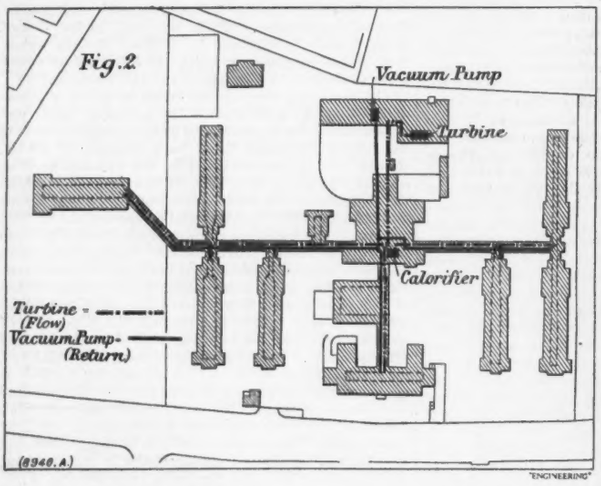


FIG. 3. ARRANGEMENT OF DISTRIBUTION PIPES.

driven three-throw Pearn pump, operating automatically as required, which in practice is about 20 minutes in every hour. The small capacity of this feed tank minimises the loss of heat between the return circuit and the boiler, and enables it to serve as a convenient measuring tank for the steam taken by the turbine. The vacuum pump is controlled by switches, which operate independently and automatically to start the pump either when the vacuum falls below 13 in. or when the level of the water in the closed receiver rises above a certain height. The constant maintenance of vacuum in the return system serves to prevent the return mains from becoming full of water, and thus to reduce loss of heat. In practice the pump is found to run about 1 minute in every 10, varying of course according to the changes in external temperature and the amount of condensate to be returned.

The arrangement of the distribution pipes has been particularly well considered. They are lagged with asbestos rope, fibre filled, and covered with canvas, the flow, return, and hot-water pipes from the calorifier being painted with distinctive colours, so as to be immediately recognisable at any point. They are carried from the roof, as shown in Fig. 3, and in the return the condensate is lifted up to the receiver of the vacuum pump in a series of steps, the water being drawn up the vertical legs by the vacuum. The depth of each step has been kept small enough to prevent the pipes from being visible through the arches.

The elements of this installation are, for the most part, well known in practice, and perhaps its chief interest lies in its overall results. Mechanically it is remarkable for being a single-unit plant without any stand-by. This apparently adventurous economy was decided on in the light of Messrs. Greenwood and Batley's previous experience with similar installations, and up to now it has been justified by the behaviour of the present plant, which has been running continuously night and day since October 15 last. Economically it has saved the institution some 8,000 to 10,000 units of current, which in previous years had to be taken from the town supply mains at a cost of 2½*d.* to 3*d.* per unit, and, in addition, the institution's fuel bill in the last quarter of the year was about 25 per cent. less than in the corresponding quarter of 1923, when it was about 479*l.* These figures, obtained while running at from a fourth to a third of the full load for which the plant was designed, obviously understate the measure of economy that the institution will secure when its extensions enable it to work the plant at something nearer full load. They are sufficient, however, to show the very considerable economy to be obtained by the system, even with the present unfavourable loading.

In addition to the makers, we have to thank Mr. F. Nicholson, the engineer of the hospital, by whom all the pipework was carried out, and Mr. Frank Lee, its President, for the opportunity of inspecting the plant and for information in regard to it.

ACROSS AUSTRALIA BY MOTOR-CAR.—A remarkable motor-car run has been made by Mr. Francis Birtles, an Australian explorer, who has driven a six-cylinder Oldsmobile car across the Australian Continent from Darwin, Northern Territory, to Adelaide, South Australia, a distance of 2,091 miles, in 9 days 9 hours and 15 minutes; 100 gallons of petrol were used, so that an average of 20·91 miles were covered per gallon of fuel expended. Supplies of lubricating oil and fuel were sent forward, months in advance, mostly by camel teams. At each depot the petrol was buried about 4 ft. under the earth to avoid undue evaporation. The path for most of the route is very rough, being simply a camel track, and on many occasions during the run it had to be abandoned, the car then travelling over virgin country. Shell oil and petrol were used throughout.

WOODWORKING MACHINERY.

THE various attempts which are being made to introduce alternative building methods are directed in the main to the elimination of brickwork and plaster, owing both to the shortage of labour and to the indifferent output of such labour as is available for working in these materials. The new methods do not as a rule seek to eliminate joinery, which holds and is likely to continue to hold, a very important position in the building trades. In these circumstances Messrs. Thomas Robinson & Son, Limited, of Railway Works, Rochdale, would appear well advised in making such an excellent and complete display of woodworking machinery at the Manchester Building Trades Exhibition, which opened at the City Hall, Deansgate, on Tuesday last. This display covers moulding and planing machines, saws, tenoning and mortising machines, universal woodworkers, &c. From this interesting collection we have chosen three machines for illustration and description. Some of these are of heavy type and may perhaps be thought to have no great relation to our remarks about alternative building methods which are, of course, concerned in the main with small property. Even in this field, however, heavy-duty high-class machines are necessary if good work is to be obtained at the minimum cost, while present building activity is also much occupied with large office buildings and similar elaborately fitted structures. The machinery shown naturally appeals to many others than builders, and will, for instance, be of particular interest to those who are concerned with the present intensive building of railway rolling-stock.

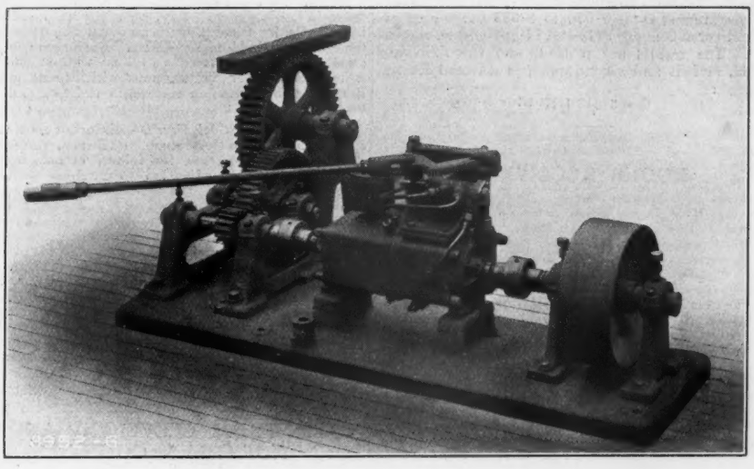


FIG. 9. HYDRAULIC VARIABLE SPEED GEAR FOR LOG SAW CARRIAGE.

The first machine which we propose to describe is shown in Figs. 1 to 4 on Plate XVIII. It is a hollow chisel mortiser. This is a powerful machine which has a large field in heavy joinery. It can, if required, be fitted with a boring head, and is shown with this addition in the general view given in Fig. 4. The outline views given in Figs. 1 to 3 show the machine in its simpler form. Machines of this class are not of great complexity, and the details of the arrangement will be followed without difficulty from our illustrations. The frame is a single cored casting with an extended base, which carries the table pedestal. The table, which is provided with quick longitudinal and cross traverse motions, is arranged to rise and fall on the pedestal by means of a central screw which is operated by the handwheel on an inclined shaft. This is clearly shown in Figs. 2 and 4. The table traverses are operated by rack and pinion from the handwheels at the front of the machine. A quick-acting cramp, which is well shown in Figs. 1, 2 and 4, is mounted on the table. It can be instantly moved across to suit the work in hand, and is fitted with a screw and ratchet to give the final pressure.

The mortising is performed by a square hollow chisel surrounding a revolving auger. These are both mounted on a vertical slide carried in guides in the head of the machine. This slide is traversed up and down by a vertical screw, which is driven through the bevel gearing to be seen below the head in Figs. 1 and 4. The driving member of this pair of bevels is keyed to a horizontal shaft which connects with a clutch box at the back of the machine. This contains two expanding friction clutches running in opposite directions in an oil bath. They are controlled by a hand lever connected with the clutch box through two short levers and a horizontal rod. The arrangement, which will be followed from Figs. 1 and 4, gives complete control over the movement of the slide from the front of the machine. A vertical rod connected to the hand lever forms an automatic cut-out for the feed. Adjustable stops on this rod enable any depth of mortise within the capacity of the machine to be cut accurately, and to be repeated as often as desired. The stops allow the chisel to be run continuously, reversing taking place automatically at each end of the travel. The auger spindle is mounted on double row ball bearings enclosed in a dust-proof housing, and is belt driven from the shaft at the back of the machine over guide pulleys, as shown in Figs. 1 and 3. The driving shaft, as will be seen from Fig. 1, is fitted with fast and loose pulleys, and the main driving belt forks are thrown over by a treadle which, like all other control motions, is operated from the front of the machine.

The maximum vertical range of the chisel is 8 in., and the machine will take chisels up to 2-in. square, to cut 6 in. deep. The boring attachment, which is shown in the general view given in Fig. 4, will bore holes up to 3-in. diameter and 12-in. deep. The spindle is mounted on ball bearings and the chuck takes auger shanks $\frac{3}{4}$ in. diameter by 2-in. long. The boring head is driven from a small separate countershaft. The overall dimensions of the machine are 8 ft. by 3 ft. 6 in., and it requires about 8 h.p. to drive it.

The second of Messrs. Robinson's machines, which we illustrate, is a double-surface planing, thicknessing and sizing machine. This is shown in the drawings, forming Figs. 5 to 8 on Plate XVIII, while a general view of the tool is given in Fig. 12, on page 292. This is a heavy-duty machine capable of large outputs in both hard and soft timbers. The machine is built either as a four-cutter planing and sizing machine, as shown in our figures, or as a double-surface planer only. The four-cutter machine is of particular value for sizing timber by finishing it at once on all four sides. The table which carries the work may be raised and lowered by power to suit the thickness of the work, while the outer vertical spindles or side-heads may be adjusted to suit the various widths of board to be dealt with. The sizing machine is essentially the double-surface planing machine, with the additional parts which are shown at the left-hand side of Figs. 5, 6 and 12, carrying the vertical spindles or side-heads.

The machine consists of a main frame, inside the cheeks of which the table is accommodated. Three feed rollers and the upper cutter blocks are carried in the upper part of the frame, while three lower feed rollers and the lower cutter blocks are associated with the table. These various parts are best shown in Fig. 5, from which it will be seen that a further out-feed roller is added when the machine is fitted with side-cutters. The main table rests on long, inclined slides, or wedges, so that by traversing these wedges horizontally the table may be raised or lowered to suit different thicknesses of timber. This wedge arrangement is clearly indicated in Fig. 5. It is traversed by means of a lead screw, which is operated by hand from the large handwheel shown at the bottom right-hand corner of Fig. 5, and also to be seen in Fig. 12. Power movement for the table is also fitted, operated from the hand lever at the right-hand side of the machine in Fig. 7. A safety stop is fitted in connection with this gear to disengage the power motion when the table has reached its highest position. A graduated index on the front of the machine indicates the height of the table. The total range is indicated in Fig. 5. A subsidiary table, which is also mounted on inclined slides, is provided in front of the bottom cutter-head for adjustment to suit the stock fed. This subsidiary table can be seen in Fig. 5. It is adjusted by the handwheel, which can be seen in the end view, Fig. 7. As will be clear from this figure, it operates the table through two worm drives. The adjustment of the side cutters is carried out from the handwheel with the long inclined shaft, to be seen in Figs. 5 and 6. The moving cutter bracket is carried on horizontal slides, and is traversed by a lead screw operated from the inclined shaft through skew gear. The arrangement is clearly shown in Figs. 5, 8 and 12.

The feed rollers are 7 in. in diameter, and are all driven by spur and roller-chain gearing, as indicated in Figs. 5, 6 and 7. The roller spindles are carried on ball bearings and all gearing is enclosed in sheet-steel covers, as shown in Fig. 12. The machine is driven from a countershaft, the belt drive for the feeds being taken to the lower pulley, which is to be seen at the lower right-hand corner of Fig. 7. A vee-belt variable speed gear is incorporated in this drive, and a speed range of from 20 to 100 ft. per minute can be obtained on the standard machine. A speed of feed ranging up to 150 ft. per minute can be arranged for if desired. The variable speed gear is of the well-known expanding and contracting pulley type, and the feed may be quickly adjusted, while the machine is running. A belt-tightening device operated from the lever which can be seen at the right-hand end of Fig. 5 is incorporated in this drive. The lever, as will be seen, is provided with a notched quadrant, so that it is held in any position to which it may be moved. The pressure on the first pairs of rollers is maintained by weights and a lever system giving considerable flexibility. These rollers, of course, have to handle the wood in a rough state before it has reached the cutters. In addition, the first two top rolls are of the maker's flexible type and will feed through several pieces of timber at one time, even though they may vary slightly in thickness. The back rollers are fitted in adjustable heads.

The cutter-blocks are circular, and in standard machines each carry four knives. Six knives may however be arranged for if desired. The cutter-blocks are driven by belts direct from the countershaft, as will be clear from the belt pulley arrangement, shown in Figs. 5 to 7. The upper cutter-block which may have most of the work is driven from both ends. The bottom cutter-block is mounted in a slide and is arranged to draw out from the machine to give proper access to the cutters. The arrangement will be quite clear from Figs. 5 and 12. Truing devices are fitted consisting of small sticks of emery carried on adjustable holders, which are moved by hand on V-slides parallel to the axes of the cutterblocks. The chip-breaker, or pressure, in front of the top cutter-block is in the form of sectional steel shoes which hold the work close to the cutting circle and at the same time adapt themselves to irregularities in the timber. The pressure over the bottom cutter-block is also of the sectional type. The chip-breaker and pressure bar behind the top cutter-block are mounted in circular guides concentric with the cutter-block, so that they cannot lift into the cutter track even when the heaviest cuts are being taken. A radial type chip-breaker, or side pressure, is fitted to the left-hand side cutter. There is also a limit or safety gauge at the feeding-in end to prevent timbers too wide being fed into the machine. This is adjusted simultaneously with the left-hand cutter-head. Both the double surface planer and the four-cutter planing machine are built in three sizes, the largest planing timber up-to 30 in. by 7 in., and occupying a space of 17 ft. by 9 ft. 6 in. or 10 ft. 6 in. A machine of this size takes 30 to 40 horse-power to drive it.

The last of the three machines, forming part of Messrs. Robinson's exhibit, which we propose to describe is a large vertical log band mill, which is illustrated in Figs. 9 to 11 above, and on page 292. This machine, which is capable of a very high output is adapted for opening-up and quartering logs and cutting wide boards and scantlings. It can deal with either large or small logs and also those that are tapered or crooked. The mill, which turns out very accurate work, consists of the saw and the log carriage. We may first deal with the latter, of which an independent view is given in Fig. 11, while it is seen behind the carriage in the general view of the mill given in Fig. 10. As wil be seen, the saw frame is of very stiff construction with a heavy, wide base. The design gives a large open gap for quartering logs, while the length of the saw is reduced to a minimum. The machine is built with saw pulleys either 6 ft., 7 ft. or 8 ft. in diameter, depending on the work for which it is required. The upper pulley is built up

with steel spokes and a weldless hard steel rim, the lower pulley being of the plate type. Both pulley shafts run on double-row self-aligning ball bearings. The pulleys are fitted on tapered seats on the shafts and are secured by fine thread lock nuts. This type of mounting ensures that the pulleys always maintain their correct alignment.

The slide carrying the upper pulley is raised and lowered by two vertical lead screws operated from a hand wheel at the left-hand side of the machine through chain and worm drives, as clearly shown in Figs. 10 and 11. The slides carry with them the straining gear which puts the necessary strain on the saw to suit the nature of the timber being dealt with. The strain is put on by the weighted lever at the back of the frame, which is best seen in Fig. 10. The lever mechanism connecting this lever with the cross bar which carries the connecting links is mounted on hardened-steel knife-edges, making it very sensitive and ensuring a uniform tension during the expansion and contraction of the saw, while working. The arrangement allows a low straining weight to be used, so that the saws are easy to keep in good condition. The connecting links from the cross bar to the pulley bearings can be seen in Figs. 10 and 11. These bearings are mounted on short swinging arms pivoted to the top of the adjusting brackets, and the pressure applied by the straining weight tends to lift these short arms and thus maintains the necessary strain on the saw. The top saw guide is arranged to release itself automatically should the timber foul it. It is traversed up and down by power by a lead screw operated through bevel gearing, as shown in the figures.

The log carriage may be built up either on a steel underframe, as shown in Fig. 10, or on a wooden frame. The arrangements for gripping the log and feeding it forwards towards the saw and for traversing the carriage are the same in either case. The standard carriage is 24 ft. long and carries four head blocks for holding the log. Longer carriages, fitted with more head blocks, may be employed when the size of the logs being dealt with demands it. The carriage is usually arranged to travel with speeds up to 100 ft. per minute. It can be arranged to be traversed either by a rack and pinion or by a wire rope, as shown in Fig. 10. In either case speed variation may be obtained either by friction gear or by the maker's variable-speed hydraulic gear. A gear of the latter kind arranged for driving the carriage through a rack is shown in Fig. 9, on page 289. This gear gives complete control by a single lever for varying the speed of the carriage both when feeding and returning.

The head blocks are each fitted with gripping dogs of the double type, gripping both the top and bottom of the log at the same time. They are actuated together by a single lever, as will clearly be seen from Fig. 10. Pulling down the lever brings the slide carrying the upper dog downwards and pushes that carrying the lower dog upwards. A ratchet and pawl hold the lever in whatever position it is pulled into. The head blocks can be independently adjusted for position to suit taper or crooked logs, being operated by the levers working around notched wheels, which can be seen in Fig. 10. A single central lever allows all the head blocks to be moved in towards the saw together. The ratchet set-works, which feed the log in, are operated through double-purchase machine-cut gearing. They are controlled by the lever working alongside the large sector, which can be seen on the second head block opposite the driver's platform in Fig. 10. A large indicating dial shows the distance of the saw from the head blocks, and adjustable blocks are provided for setting up when a number of boards of one size are to be cut. The lever to be seen behind the one to which we have just referred in Fig. 10, is used to disengage the ratchets. The power-driven recede motion which enables the head blocks to be withdrawn the full width of the carriage during a single return movement is thrown into gear by a friction clutch, controlled by the lever to be seen to the left of the driver's platform in Fig. 10. An automatic off-set motion withdraws the log from the saw on the return after each cut. Before the next cut begins the carriage automatically advances. In the case of a false cut a conveniently placed lever throws the off-set gear out of action so as to bring the log back in the line of the cut.

FROM SAIL TO STEAM.—The history of British shipbuilding from the dawn of the Christian era down to modern times, is told in an attractive manner in a volume entitled "From Sail to Steam," by Messrs. William Gray and Co., Limited, shipbuilders and engineers, of West Hartlepool. The work is divided historically into five sections and contains many fine illustrations of vessels in service at various periods. The firm is to be congratulated on having succeeded in retaining sufficient historical data to maintain a logical account of the development of the modern steamer, whilst avoiding too much detail. A brief sketch of the firm's history is included. The work is published by Dr. G. Schueler, Dale-street, Liverpool.

MEASUREMENT OF DISCHARGE OVER A ROCK-FACED DAM.*

By PROFESSOR S. M. DIXON, and F. W. MACAULAY, MM.Inst.C.E.

THE Water Committee of the City of Birmingham desired to ascertain as accurately as possible the yield of the Elan gathering-ground. To determine this it was necessary to estimate closely the quantity of water flowing over the Caban dam, which is rock-faced with a flat crest. A full-size model of a short length of the dam was made in reinforced concrete. This model was placed in a gap cut in the Nant-y-gro dam, and the water flowing over was passed through a timber flume to a specially constructed reinforced-concrete measuring-tank. The length of the dam used (3 ft.) was chosen with reference to the available water and the tank was designed to be suitable for measuring this water. The head was kept as nearly constant as possible during the whole time of any given experiment, and was measured by three hook gauges reading directly to $\frac{1}{1000}$ in. By means of a hatch door in the bottom of the timber flume, the water flowing towards the measuring tank could be instantly diverted. End contractions were suppressed by timber wings extending into the reservoir, and there was no velocity of approach. Thirteen complete experiments were made, at heads ranging from 0·076 to 1·393 ft., the quantities delivered being 0·1998 and 14·807 cusecs, respectively. The results are plotted, and the following formula, in foot and second units, is deduced for the discharge :

$$Q = 3{\cdot}043\ L\ H^{1{\cdot}484}$$

BOOKS RECEIVED.

United States Geological Survey. Bulletin No. 750–D. *New and Well-Known Minerals from the Utah–Colorado Carnotite Region.* By F. L. HESS. No. 750–E. *Deposits of Magnesia Alum, Near Fallow, Nevada.* By D. F. HEWETT. No. 750–F. *Molybdenite in the Rocky Bar District, Idaho.* By F. C. SCHRADER. No. 751–C. *Geology and Possible Oil and Gas Resources of the Faulted Area, South of the Bearpaw Mountains, Montana.* By F. REEVES. Washington: Government Printing Office.

United States Geological Survey. Water-Supply Paper No. 517. *Water Powers of the Great Salt Basin.* By R. R. WOOLEY. [Price 30 cents.] No. 521. *Surface-Water Supply of the United States,* 1921. Part I. *North Atlantic Slope Drainage Basins.* [Price 25 cents.] Washington: Government Printing Office.

Transactions of the American Institute of Mining and Metallurgical Engineers, Vol. LXX. New York: Offices of the Institute.

A Manual of Locomotive Running-Shed Management. By WALTER PATERSON and HARRY WEBSTER, B.Sc. London: Charles Griffin and Co., Limited. [Price 15*s.* net.]

Principles of Transmission in Telephony. By M. P. WEINBACH. New York: The Macmillan Company. London: Macmillan and Co., Limited. [Price 17*s.* net.]

The Chemical Coloring of Metals and Allied Processes. By SAMUEL FIELD, F.C.S., and SAMUEL R. BONNEY. London: Chapman and Hall, Limited. [Price 10*s.* 6*d.* net.]

The "Electrician" Electrical Trades Directory and Handbook, 1925. London: Ernest Benn, Limited. [Price 25*s.* net.]

United States Geological Survey. Mineral Resources of the United States. I : 10. *Lead and Zinc Pigments and Salts in* 1923. By C. E. SIEBENTHAL and A. STOLL. I : 11. *Lead in* 1923 (*Smelter Report*). By C. E. SIEBENTHAL and A. STOLL. I : 12. *Manganese and Manganiferous Ores in* 1923. By H. M. MEYER. I : 13. *Arsenic in* 1923. By V. C. HEIKES and G. F. LOUGHLIN. I : 15. *Rare Metals. Cobalt, Molybdenum, Nickel, Tantalum, Titanium, Tungsten, Radium, Uranium and Vanadium, in* 1923. By F. L. HESS. I : 16. *Secondary Metals in* 1923. By J. P. DUNLOP. Washington: Government Printing Office.

United States Geological Survey. Mineral Resources of the United States. II : 14. *Mineral Waters in* 1923. By W. D. COLLINS. II : 18. *Sand and Gravel in* 1923. By A. T. COONS. II : 19. *Talc and Soapstone in* 1923. By B. H. STODDARD. II : 22. *Silica in* 1923. By F. J. KATZ. Washington: Government Printing Office.

United States Geological Survey. Bulletin No. 751E. *The Scobey Lignite Field Valley, Daniels and Sheridan Counties, Montana.* By A. J. COLLIER. Professional Paper No. 132-F. *Relations of the Wasatch and Green River Formations in North-western Colorado and Southern Wyoming, with Notes on Oil Shale in the Gwen River Formation.* By J. D. SEARS and W. H. BRADLEY. No. 132-G. *Discovery of a Balkan Fresh-Water Fauna in the Idaho Formation of Snake River, Idaho.* By W. H. DALL. No. 132-H. *The Resuscitation of the Term Bryn Mawr Gravel.* By F. BASCOM. Washington: Government Printing Office.

Notes and Data on Railway Engineering (Way and Works). By FRANK REEVES, M.Inst.C.E. London: Charles Griffin and Co., Limited. [Price 15*s.* net.]

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* Abstract of a paper to be read before the Institution of Civil Engineers on Tuesday, March 10, 1925.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Contrary to general anticipation, the last two months have failed to furnish any signs of improvement, and, on the whole, the position does not compare favourably with that at the end of last year. Some sections of local industry have lost ground. Included in these are departments dealing in raw and semi-finished steel, forgings, castings and scrap, while the output of crucible steel has diminished to below the December level. It is possible, however, to find branches which are experiencing busy times and perhaps the most prominent is that engaged in the manufacture of railway material. The majority of firms so occupied are still working on the contracts recently placed by British railways. One of these firms, Messrs. Craven's Railway Carriage and Wagon Company, Limited, of Sheffield, received from the L. and N.E. Railway an order for the supply of 27 carriages. Other firms in the district will benefit indirectly. Automobile steel producers are fairly busy, and a large proportion of the output is going away for home consumption, but the overseas demand is disappointing. An improvement is reported in the call for ship steel, marine castings and turbine parts, but the position continues to be far from satisfactory. In the lighter sections, the position is more favourable than those obtaining in the heavy trades. The call for tool steel is expanding on home account, but the operation of high foreign tariffs curtails overseas business. In the implement and machinery branches, trade is flowing more freely, especially in building and farm tools, for which there is an increasing demand both from home and colonial markets. Business in engineers' small tools and files is not so robust and, on the whole, is unsatisfactory. Transactions with Russia are more frequent, though manufacturers still insist on cash before delivery.

South Yorkshire Coal Trade.—Business continues very quiet, and the position remains unaltered. Best steams are only in fair request for inland consumption, and exporters show no inclination to purchase even at the special rates offered. The market for cobbles and nuts continues to be unsatisfactory and, if anything, displays further weakness, while slacks occupy a similar position. House coal tends to improve, especially in better sorts. Foundry and furnace coke, in spite of lower prices, are in poor request. Quotations :—Best branch, hand-picked, 30*s.* to 33*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 26*s.* to 31*s.*; Derbyshire best house, 24*s.* to 26*s.*; Derbyshire best large nuts, 22*s.* 6*d.* to 25*s.*; Derbyshire best small nuts, 14*s.* to 16*s.*; Yorkshire hards, 18*s.* to 22*s.*; Derbyshire hards, 18*s.* 6*d.* to 22*s.*; rough slacks, 10*s.* to 12*s.* 6*d.*; nutty slacks, 8*s.* 6*d.* to 10*s.*; smalls, 4*s.* to 6*s.* 6*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron continues on a very limited scale and quotations are easy. Supply is not too plentiful and a few home and export inquiries are circulating, but customers claim to experience no difficulty in shading recognised market quotations. Producers' unsold stocks are very small, and some firms have fairly good order books. Thus the statistical situation is strong, and makers are resisting buyers' efforts to secure price concessions. Sellers' quotations stand : No. 1 quality, 83*s.* 6*d.*; No. 3 g.m.b., 78*s.* 6*d.*; No. 4 foundry, 77*s.* 6*d.*; and No. 4 forge, 76*s.* 6*d.* There are buyers at sixpence below the foregoing figures.

Hematite.— East-Coast hematite makers, though hampered by rather heavy stocks, are loth to lower quotations, and they still hope for American demand. Prices, however, are on the downward curve. Nos. 1, 2 and 3 are now no more than 85*s.*, and No. 1 is quoted 85*s.* 6*d.*

Manufactured Iron and Steel.—Demand is perhaps just a trifle better in one or two branches of finished iron and steel, but the total volume of trade passing is still very disappointing. Values are upheld. Among the principal market quotations are : Common iron bars, 12*l.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 8*l.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 8*l.* 10*s.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel ship, bridge and tank plates, 9*l.* 5*s.*; steel angles, 9*l.*; steel joists, 9*l.* to 9*l.* 5*s.*; heavy steel rails, 9*l.* to 9*l.* 10*s.*; and galvanised corrugated sheets (24-in. gauge), 17*l.*

Imports of Iron and Steel.—The monthly returns of the River Tees Conservancy Commissioners give the imports of iron and steel to the Tees from Holland, Belgium, France, Norway, Sweden, Germany, India and coastwise for the four months ended February 28 last, together with the figures for the same months a year ago and the corresponding pre-war period of 1913–14. They give pig-iron arrivals in the past four months at 3,947 tons, as against 6,126 tons a year ago and 54 tons in the pre-war period; imports of plates, bars, angles, rails, and joists, up to the end of February last, at 7,513 tons, as against 4,456 tons a year ago and 7,906 tons in the pre-war period; and unloadings of crude sheet bars, billets, blooms, and slabs, to the end of last month, at 40,166 tons, as against 16,161 tons a year ago and 14,309 tons in the pre-war period.

Shipments of Iron and Steel.—February shipments of iron and steel from the Tees ports are officially returned at 82,130 tons, comprising 27,733 tons of pig-iron, 10,970 tons of manufactured iron, and 43,427 tons of steel.

Of the pig-iron cleared, 15,326 tons went overseas and 12,407 tons coastwise; of the manufactured iron despatched, 4,171 tons went to foreign ports and 6,799 tons coastwise; and of the steel shipped, 32,523 tons went abroad and 10,904 tons coastwise. Once more Scotland was the largest receiver of pig-iron, the figure being 10,518 tons, whilst the United States took 4,056 tons, Italy 2,945 tons, Belgium 1,835 tons, Germany 1,687 tons, Netherlands 1,057 tons, and France 1,045 tons. With imports of 2,609 tons, the Cape of Good Hope was by far the heaviest customer for manufactured iron. The principal receivers of steel were: Netherlands, 8,223 tons; India, 7,335 tons; Ceylon, 2,101 tons; New South Wales, 1,818 tons; Victoria, 1,702 tons; Queensland, 1,277 tons; Kenya, 1,103 tons; and Siam, 1,056 tons.

Blast-furnace Coke.—Durham blast-furnace coke is weak. Good average qualities are slow of sale at 24*s.* delivered here.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Little that is fresh falls to be recorded in connection with the Scottish steel trade this week. All round the dullness continues, and there are no signs of any betterment coming along—in fact, it might almost be said that the opposite is more likely, and that conditions will be worse before they actually get the turn. Specifications are so scarce that much plant is lying almost wholly idle, and inquiries are also very poor. Over all, the outlook is not at all bright. In the steel-sheet trade, there has been little change. For the heavy gauges, there is a very slow demand, but light and galvanised qualities are the subject of quite good business, and fairly regular bookings are general. Prices are just steady, and the following are the market quotations:—Boiler plates, 13*l.* per ton; ship plates, 9*l.* 15*s.* per ton; sections, 9*l.* 10*s.* per ton; and sheets, $\frac{5}{16}$ to $\frac{1}{4}$ in., 12*l.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The West of Scotland malleable-iron trade continues to move very slowly, and fresh business amounts to very little. Buyers are keeping out of the market and inquiries are few. The steel re-rolling branches are also quieter, and business is rather more difficult to pick up. Prices are unchanged with "Crown" bars at 12*l.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—The outlook in the Scottish pig-iron trade has not improved since the last reduction in output. Any business on offer is very keenly competed for, not only locally but from outside sources, with the result that few fresh lines are being obtained on anything like paying conditions. Home consumers are buying next to nothing at present, while export orders are extremely few. Prices are inclined to get easier and are barely steady. To-day's quotations are as follow:—Hematite, 4*l.* 12*s.* 6*d.* per ton, delivered at the steel works; foundry iron, No. 1, 4*l.* 11*s.* 6*d.* per ton, and No. 3, 4*l.* 8*s.* to 4*l.* 9*s.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipment of Scottish pig-iron from Glasgow Harbour for the week ended last Saturday, February 28, only amounted to 579 tons. Of that total, 494 tons went overseas and 85 tons coastwise. For the corresponding week of last year the figures were 463 tons overseas and 208 tons coastwise, making a total shipment of 671 tons.

Shipbuilding.—While the shipbuilding returns for the past month are, on the whole, very satisfactory, the disturbing factor is that there are so few fresh contracts on hand to take the place of the tonnage launched. The present state of the world's trade is not good, and ship owners are not inclined to place new orders until the prospects of securing paying freights are brighter. To-day's cost of construction is very high with the probability of being still higher, and that means that a holding back policy is in vogue and only vessels of an urgent or special nature are being ordered. During the past month, contracts for some eight or ten new vessels were given out, as against 16 launched.

The following are the figures for vessels launched during the month of February:—

	Vessels.	Tons.
The Clyde	12	40,936
The Forth	—	—
The Tay	1	1,400
The Dee and Moray Firth...	3	2,680
Total	16	45,016

The Clyde output is a good average, and the best for the month of February since the war, with the exception of February, 1921, when the figures were 25 vessels of 82,431 tons. The total for the year, to date, is now 20 vessels of 69,502 tons, which is, on the whole, fairly satisfactory, but a little behind some of the other years since the war.

Shipbuilding Contracts.—The latest shipbuilding contracts reported are for two shelter-deck cargo steamers, with engines amidships, instead of aft, for the General Steam Navigation Company, Limited, London. One of these vessels will be built and engined by the Ailsa Shipbuilding Company, Limited, of Troon and Ayr, while the other will be built by the Ayrshire Dockyard Company, Limited, Irvine. The engines for the latter vessel will be supplied by Messrs. Bow, M'Lachlan & Co., Limited, Paisley.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-night, at 7 p.m., at Storey's-gate, S.W. 1. Informal Meeting. Discussion on "Pitfalls for Patentees." Friday, March 13, at 6 p.m. Extra General Meeting. Reports to the Cutting Tools Research Committee: "The Action of Cutting Tools," by Professor E. G. Coker, D.Sc., F.R.S., and "Experiments with Lathe Tools on Fine Cuts, and Some Physical Properties of the Tool Steels and Metal Operated Upon," by Mr. Dempster Smith, M.Sc., and Mr. Arthur Leigh, B.Sc.

THE JUNIOR INSTITUTION OF ENGINEERS.—To-night, at 7.30 p.m., at 39, Victoria-street, S.W. 1. Lecturette: "How to Apply for a Job and how not to do it," by Mr. E. Fiander Etchells. Friday, March 13, at 7.30 p.m. Lecturette: "Notes on Methods of Producing Modern High-Grade Machine Tools," by Mr. A. P. Bale, M.I.Mech.E.

THE NORTHAMPTON ENGINEERING COLLEGE ENGINEERING SOCIETY.—Monday, March 9, at 5.30 p.m., at St. John-street, E.C. 1. "Recent Developments in the Generation and Transmission of Electric Power," by Mr. M. G. Holmes.

THE INSTITUTE OF TRANSPORT: YORKSHIRE SECTION.—Monday, March 9, at 5.30 p.m., at the Town Hall, Leeds. "The Valuation of Transport Services," by Professor J. H. Jones.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Monday, March 9, at 7 p.m., at Savoy Place, Victoria Embankment, W.C. 2. Informal Meeting. Discussion on "Illumination," to be opened by Mr. C. W. Sully.

THE INSTITUTE OF METALS: SCOTTISH LOCAL SECTION.—Monday, March 9, at 7.30 p.m., at the Institution of Engineers and Shipbuilders, Elmbank-crescent, Glasgow. "Electric Furnaces," by Mr. A. Glynne Lobley, M.Sc.

THE SURVEYORS' INSTITUTION.—Monday, March 9, at 8 p.m., at Great George-street, S.W. 1. "The Smoke Nuisance in Towns and its Abatement," by Mr. J. Gordon Elsworthy.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Tuesday, March 10, at 5.15 p.m., at Albemarle-street, W. 1. "Evolution of the Scientific Instrument," by Professor E. N. da C. Andrade. Saturday, March 14, at 3 p.m. Afternoon Lecture: "The Counting of the Atoms" (Lecture III), by Sir Ernest Rutherford.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, March 10, at 5.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. Address by the retiring President, Mr. Herbert Barringer.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, March 10, at 6 p.m., at Great George-street, S.W. 1. Ordinary Meeting. Paper to be submitted for discussion: "Measurements of Discharge over a Rock-Faced Dam," by Professor Stephen Mitchell Dixon, M.A., B.A.I., and Mr. Frederic William Macaulay, M.Inst.C.E. Wednesday, March 11, at 7 p.m. Informal Meeting. "The Relative Importance and Nature of Secondary Stresses in Steel Structures," to be introduced by Mr. John Sigismund Wilson.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Tuesday, March 10, at 7 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. "Carburation," by Mr. D. Finlayson.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—Tuesday, March 10, at 7 p.m., at the North British Waverley Station Hotel, Edinburgh. "Iron Losses in Direct-Current Machines," by Mr. E. Hughes, B.Sc.

THE INSTITUTE OF METALS.—Annual General Meeting. Wednesday, March 11, and Thursday, March 12, at 10 a.m., at the Institution of Mechanical Engineers, Storey's-gate, S.W.1. Wednesday, March 11, at 10 a.m., "The Effect of Grain-Size upon Hardness and Annealing Temperature," by Mr. H. T. Angus, M.Sc., and Mr. P. F. Summers, A.R.S.M. "A Method of Improving the Properties of Aluminium-Alloy Castings," by Mr. S. L. Archbutt, F.I.C. "Surface Abrasion as a Potential Cause of Localized Corrosion," by Mr. Ulick R. Evans, M.A. "The Influence of Emulsoids upon the Rate of Dissolution of Zinc in Solutions of Lead, Nickel and Copper Salts," by Dr. J. Newton Friend, F.I.C., and Mr. J. S. Tidmus, M.Sc. Wednesday afternoon at 2 p.m. "Comparative Tests on Some Varieties of Commercial Copper Rod," by Mr. T. G. Bamford, M.Sc. "The Alpha-Phase Boundary in the Copper-Zinc System," by Mr. R. Genders, M.Met., F.I.C., and Mr. G. L. Bailey, M.Sc., A.I.C. "The Influence of Lead and Tin on the Brittle Ranges of Brass," by Mr. Denis Bunting, M.Sc., Ph.D. "The Removal of Red Stains from Brass," by Mr. E. A. Bolton, M.Sc. At 7 p.m. for 7.30 p.m. Annual Dinner at the Trocadero Restaurant, Piccadilly Circus, W.1. Thursday, March 12, at 10 a.m. "The Density and Constitution of the Industrial Brasses," by Mr. G. L. Bailey, M.Sc., and Mr. R. Genders, M.Met., F.I.C. "Notes on the Effects of Certain Elements on the Electrical Resistivity of Copper," by Mr. A. L. Norbury, M.Sc. "On the Density of Rhodium," by Sir Thomas Kirke, D.Sc. "Some Experiments on the Abrasion of Metals," by Prof. Kotaro Honda, Sc.D., and Prof. Ryôsuke Yamada. "On the Equilibrium Diagram of the Aluminium-Zinc System," by Prof. Tomimatu Isihara.

THE INSTITUTION OF CHEMICAL ENGINEERS.—Wednesday, March 11, at 8 p.m., at the Institution of Mechanical Engineers, Storey's-gate, S.W.1. "Expansion and Compression Phenomena in Steam Jets," by Professor A. L. Mellanby, D.Sc.

THE ROYAL SOCIETY OF ARTS.—Wednesday, March 11, at 8 p.m., at John-street, Adelphi, W.C.2. Ordinary Meeting. "The Restoration of Public Buildings in Belgium," by Mr. Emile Cammaerts.

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Friday, March 13, at 7.15 p.m., at the Engineers' Club, Albert-square, Manchester. "The Application of Ball and Roller Bearings," by Mr. W. E. Baker, B.Eng.

THE INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—Friday, March 13, at 7.15 p.m., at the University College, Singleton Park. General Discussion.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, March 13, at 7.30 p.m., in the Lecture Theatre, Literary and Philosophical Society, Newcastle-upon-Tyne. "Recent Research on Cast Iron," by Mr. J. G. Pearce and Mr. J. E. Fletcher.

THE INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Saturday, March 14, at 4 p.m., at the College of Technology, Sackville-street, Manchester, Lecture: "Oil-Sand Cores," by Mr. G. Edgington.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—No improvement has taken place in the condition of the steam-coal trade during the past week. Indeed, the position, if anything, is worse, and although prices are at the lowest level for two years, business is not being attracted. In fact, although a number of collieries are stopped while those working are suffering frequent temporary stoppages, the output is still more than sufficient to meet the demand. Quotations generally are unaltered, but buyers with firm business in hand can secure concessions on the quoted figures. In one instance, best Admiralty large coal still commands 27*s.*, but other classes of bests are changing hands at 26*s.* to 26*s.* 6*d.*, with seconds from 25*s.* to 25*s.* 6*d.*, and Monmouthshires from 23*s.* to 24*s.* 3*d.*, while dry large coals rule from 23*s.* 6*d.* to 26*s.* Best steam smalls are obtainable at 15*s.* to 15*s.* 6*d.*, with inferior qualities down to 11*s.* Shipments of coal as cargo from South Wales last week amounted to only 398,010 tons, which was nearly 80,000 tons less than a week ago, and represents the smallest quantity dealt with in any similar period this year. The falling off is partly due to the lack of remunerative trade, but particularly due to a shortage of shipping, tonnage having been seriously delayed by the recent bad weather. The number of boats in the Cardiff, Penarth and Barry Docks has varied from 139 to 186 a day during the past week, compared with 224 a month ago, while from 10 to 24 tips at the docks have been idle. Tenders have been submitted in response to the French State Railways inquiry for 10,000 tons of large and 20,000 tons of small over the next three months, and it is quite probable that the offer of more than one firm will be accepted for the total quantity. The Great Southern Railway of Ireland are also inviting offers for 120,000 tons of large over six months or 240,000 tons over 12 months. The fact that the Miners Federation of Great Britain conference ended without any drastic decisions, and left the door open for negotiations in connection with the wages agreement, which terminates in June, is regarded as a sign that the miners recognise that nothing can be gained by striking, and it is believed that an agreement between the owners and the miners will eventually be reached without recourse to strike action. At any rate, a stoppage of work would only result in what little trade is coming to this country being driven abroad.

Iron and Steel.—Exports of iron and steel goods from South Wales in the past week totalled only 8,420 tons, which, however, was 3,800 tons more than in the preceding week. Shipments of tinplates and terneplates totalled 7,017 tons, against 3,014 tons; blackplates and sheets 577 tons against 395 tons; galvanised sheets 530 tons against 657 tons; and other iron and steel goods 295 tons against 533 tons.

LLOYD'S REGISTER SCHOLARSHIPS.—It is announced that one of the three scholarships awarded by Lloyd's Register of Shipping entitling the recipient to a university training in engineering, will be available this year, for which award qualifying examinations will be held in May. Intending candidates (who must be between the ages of 18 and 23 years) are required to submit their names before March 10. Further particulars may be obtained on application to the Institute of Marine Engineers, 85-88, The Minories, Tower-hill, London, E.1.

TENDERS.—The Department of Overseas Trade, of 35, Old Queen-street, London, S.W.1, announce that the port authorities at Montevideo (Uruguay) have issued a call for tenders, to be answered by May 7, 1925, for the execution of works in the free zone of Nueva Palmira. Further, the South African Railways and Harbours Administration are inviting tenders, until April 20, 1925, for the supply and delivery f.o.r. in Durban of two 10-ton steam-driven locomotive cranes. The Egyptian Ministry of the Interior are calling for offers, to be presented by April 15, 1925, for the supply and erection of a steel reservoir. The Greek Refugee Colonisation Department are interested in obtaining quotations from British manufacturers for threshing machines, straw cutters, presses, and reaping and binding machines. All inquiries regarding these announcements should be addressed to the Department.

WOODWORKING MACHINERY AT THE MANCHESTER BUILDING EXHIBITION.

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(*For Description see Page* 289.)

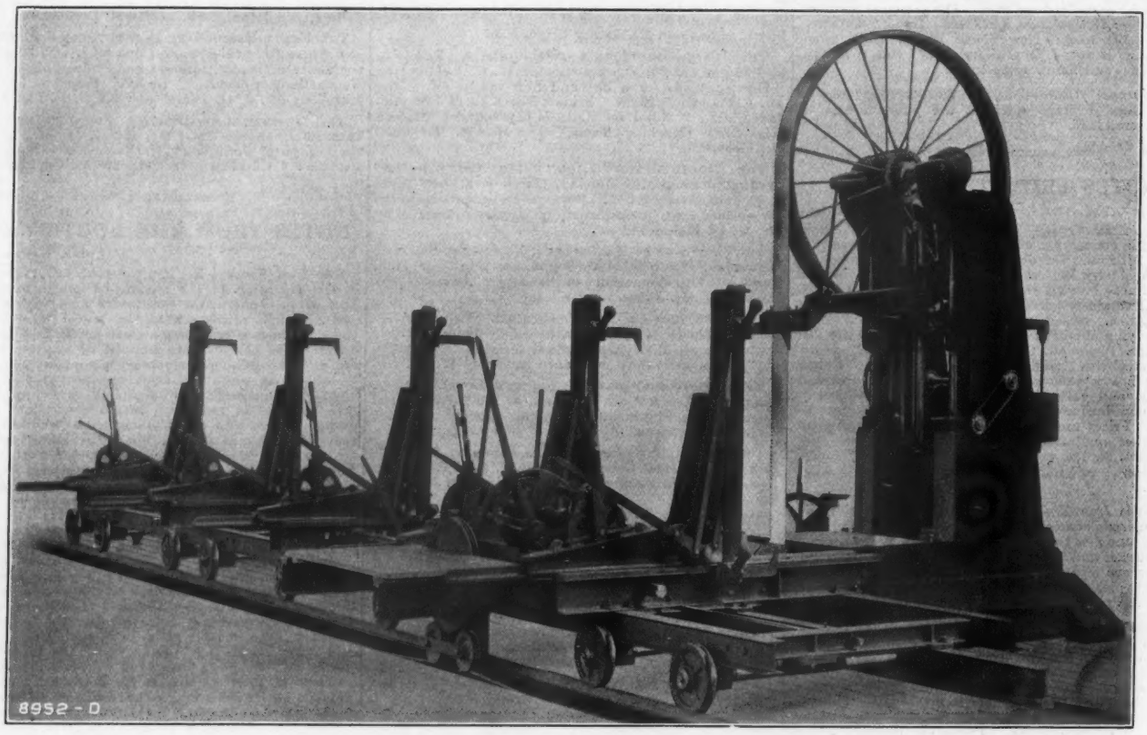

FIG. 10. VERTICAL LOG BAND MILL.

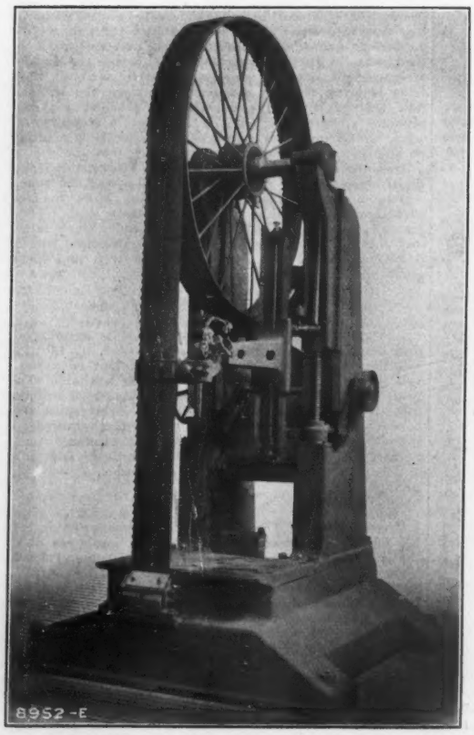

FIG. 11. SAW STANDARD FOR LOG MILL.

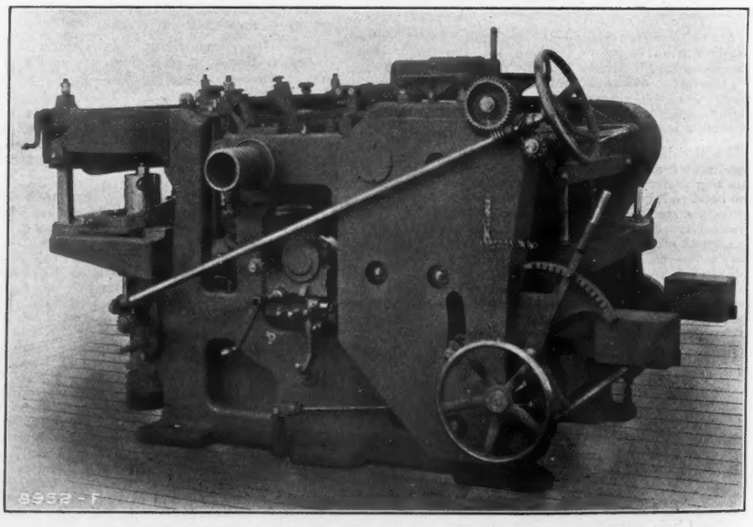

FIG. 12. SURFACING, THICKNESSING AND SIZING MACHINE.

INDUSTRIAL GASES.—From the last quarterly issue of *Industrial Gases* we learn that the journal is now recognised by the British Acetylene and Welding Association as the organ which directly represents the acetylene industry. Some examples of recent work in welding, which are described in this number, afford evidence of the continued development of this industry. The joining of cast-iron pipes by bronze welding is illustrated in reference to the formation of a metal lining for an artesian well. Another interesting example of recent work is afforded by an article on "180 Miles of Welded Pipe Line." This refers to a pipe line for an American oil company. Wagons carrying acetylene generators, dissolved acetylene containers and oxygen bottles, were taken up to the pipe line. First the individual pipes were welded together, by the use of acetylene from the generators, into suitable sizes for handling and then, for "tieing-in" these sections, the ends were belled all round where the joints were to be made. For this purpose dissolved acetylene was used. When the first section of the line, of 93 miles length, was put under a hydraulic pressure of 140 lbs. per square inch only one bad joint and three pin-holes were detected, and these defects were soon remedied.

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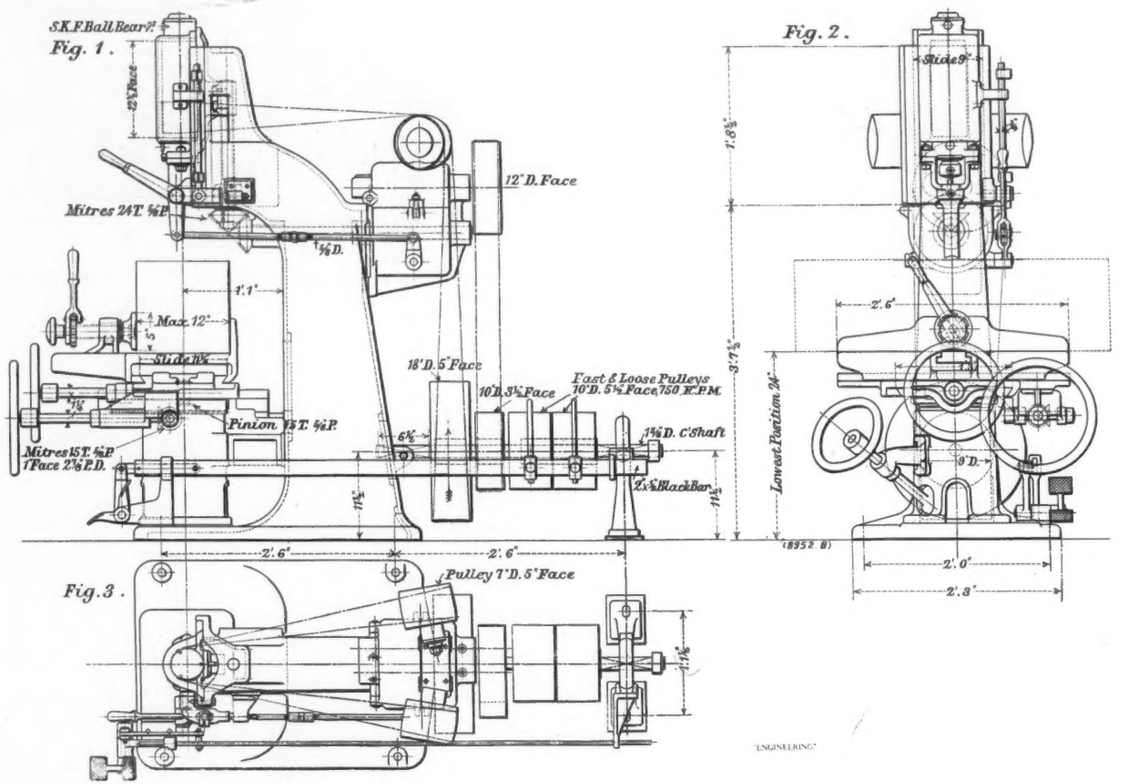


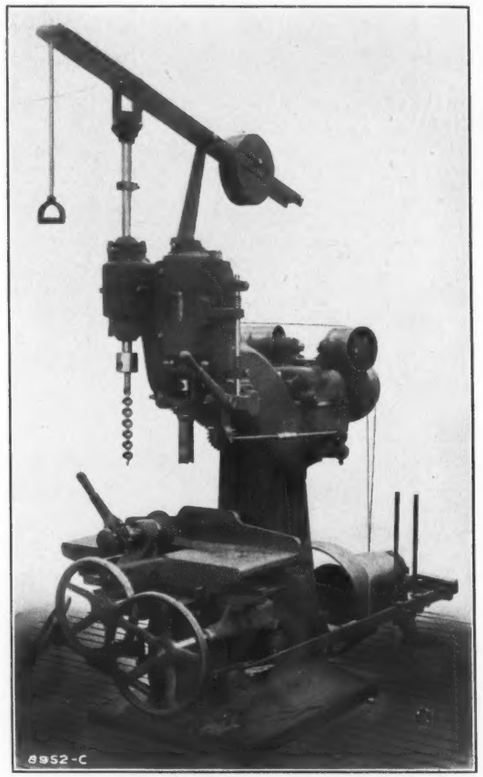
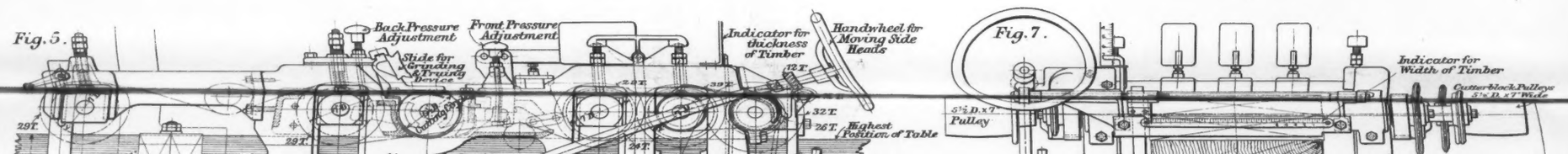


Fig. 4.

Figs. 1 to 4. Automatic Hollow Chisel Mortising Machine.



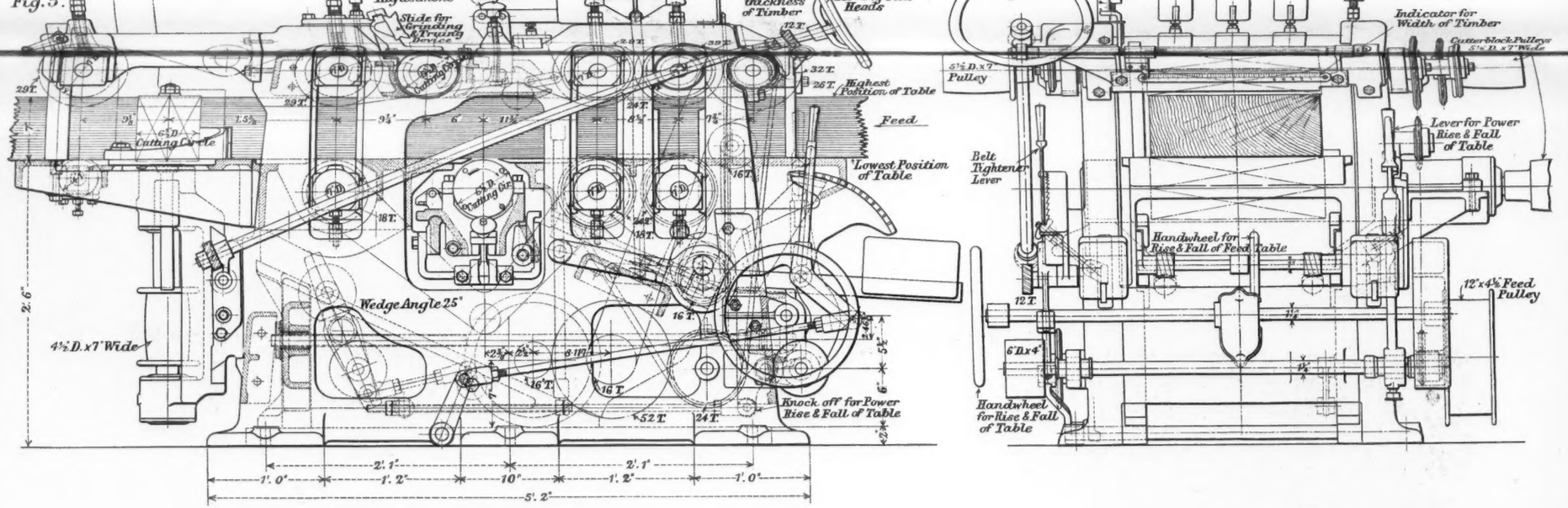
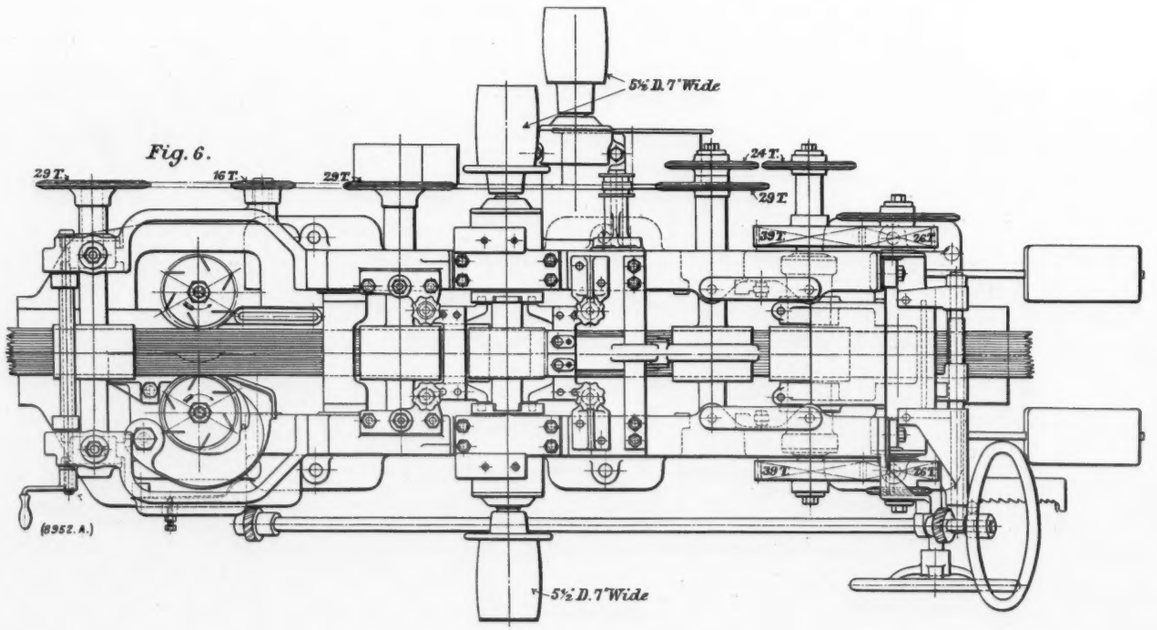
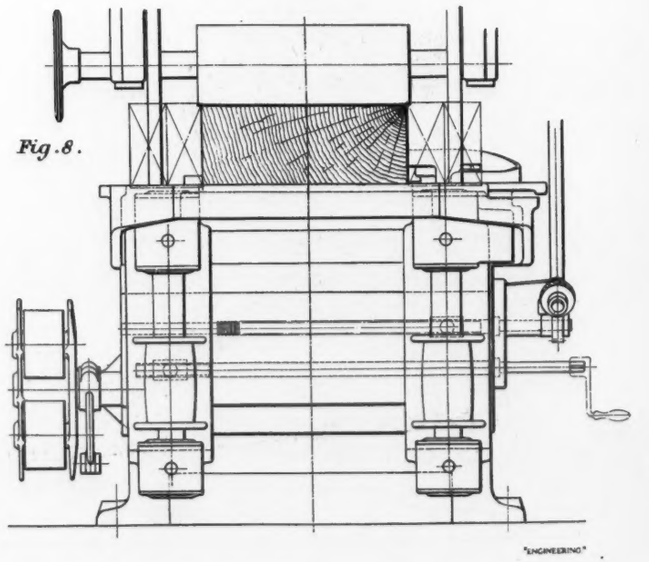


Fig. 5.
Indicator for Thickness of Timber
Heads
Indicator for Width of Timber
Cutter-block Pulleys 5½" D. x 7" Wide
5½" D. x 7" Pulley
Slide for Grinding & Truing Device
Highest Position of Table
Feed
Lowest Position of Table
Lever for Power Rise & Fall of Table
Belt Tightener Lever
Handwheel for Rise & Fall of Feed Table
12" x 4¾" Feed Pulley
Wedge Angle 25°
4½" D. x 7" Wide
Knock off for Power Rise & Fall of Table
Handwheel for Rise & Fall of Table
2'. 6"
2'. 1"
1'. 0"
1'. 2"
10"
5'. 2"





FIGS. 5 TO 8. DOUBLE-SURFACE PLANING, THICKNESSING AND SIZING MACHINE.

ENGINEERING.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

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TASMANIA: Gordon & Gotch Prop'ty, Ltd., Launceston: Hobart.

UNITED STATES: For Subscription, New York: W. H. Wiley, 440, Fourth Avenue. For Advertisements: J. S. Allan, 30, Church Street, New York.

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Two-Page Plate.—WOODWORKING MACHINERY AT THE MANCHESTER BUILDING EXHIBITION.

ENGINEERING.

FRIDAY, MARCH 6, 1925.

THE SINGAPORE BASE AND PRACTICAL NAVAL STRATEGY.

IN the debate in the House of Lords on Wednesday the Government had no difficulty in demonstrating that the Singapore Dockyard would represent a normal development of naval policy, and that although certain sections of opinion in Japan had felt some suspicion that the works at Singapore indicated a lack of confidence on our part in the peaceful intentions of our former Allies, in Japanese official and well-informed circles the true nature of the situation was fully realised. The project of setting up a battleship base at Singapore is indeed an essential measure in an organised scheme of imperial defence and one may assume will be one of the subjects to occupy the attention of the Conference of Flag Officers now meeting at Singapore. The principal argument of those who have consistently advocated the plan of a new dockyard at this port is that the mobility of a modern fleet depends, in the last resort, upon the position of bases from which it can operate. Without a chain of bases connecting our Dominions and outlying possessions to Great Britain, an adequate naval defence of our Colonies, or our essential trade routes, is impossible; and, unless a base is erected at Singapore, no British battle fleet can ever hope to operate in the Pacific. The argument is unanswerable, and it is worth while to investigate some of its technical implications. These fall into two divisions. First, what are the strategic possibilities of the Pacific theatre; that is, if any power undertakes great military movements in the ocean, what will they imply? Secondly, what part will the base play in the defence of the imperial trade routes?

Overseas expeditions depend for their bare existence upon ordinary commercial shipping. No power can undertake them, unless it can withdraw the shipping necessary from ordinary commercial uses, and make good the deficit, either by intensive building or hiring neutrals, or both together. Fully equipped, modern armies absorb shipping to an extent which was not realised before 1914. In 1917, no less than 8 million tons of British shipping had to be set apart for purely military purposes, and this enormous figure excluded ships which were carrying stores and essential supplies on government account. This, however, only shows the magnitude of the problem: the matter has to be examined rather more closely.

Analytical statistics have proved that, when the American expeditionary force was taken to France, each vessel employed on the service covered, on the average, 3,500 miles per month, allowing for the necessary stays in port at either end of the voyage; and that every man required 2 tons of shipping to carry him to the theatre of war, and 1 ton per annum to keep him there. The distance that each ship could cover per month was based on the fact that, on an average, every vessel in the service completed six round voyages of 7,000 miles per year.

When these data are applied to the enormous distances in the Pacific we arrive at rather startling results. The distance from San Francisco to Manila is 6,220 miles; from Panama to Manila is 8,000 miles. The average round trip is thus about 14,000 miles, so that twice as much tonnage per armed man would be absorbed by a military force sent to reinforce the Philippines, as was taken up by the American armies in France. The figures would be at least 4 tons per man for the original expedition, and 2 tons per man per year for the necessary flow of supplies. Should the Philippines ever become the theatre of a serious struggle, an army of 300,000 men would thus deflect 1,200,000 tons of American shipping from commercial uses before it could even be landed.

It is not necessary to go through the same calculation in detail for the Japanese. It will be enough to state the results; but, before doing so, it is necessary to add a caution. The shipping figures for the American expeditionary force were based upon the very important fact that the American armies were landed at well-equipped ports, which were ready to receive them. Each transport was able to cover 3,500 miles per month, because she was unloaded with the greatest possible rapidity. The absorption of tonnage due to port delays is very much greater if an expeditionary force has to be landed in hostile territory, against resistance. The port delays of the ships attached to the Dardanelles expeditionary forces were roughly double those of the transports employed in the French service. It can, therefore, be assumed that Japanese transport or supply ships engaged in Pacific operations would not cover more than 2,000 miles per month. These purely technical considerations fully confirm the frequent declarations of Japanese statesmen—that they have not the slightest intention of ever undertaking an aggressive or adventurous policy. About 1,300,000 tons of shipping would be required to carry a Japanese expeditionary force of 300,000 men (a comparatively small force in modern warfare) to any possible objective. The country at present possesses some 3,600,000 tons of shipping; and she is so dependent upon foreign supplies that she could not possibly release one-third of her total shipping for military purposes by cutting down imports. In war, when they would be enormously increased, she would be less able to do so than ever.

Similarly, these figures prove, once and for all, that the battleship base at Singapore cannot possibly be intended for any aggressive purpose. No British Government would ever dream of sending a military expedition to the Far East; simply because the country's resources do not permit of it. The enormous mass of tonnage necessary would have to be built specially, for only a portion of it could be withdrawn from commercial uses. To this would have to be added an immense fleet of colliers carrying coal to all the coaling stations along the route, for bunkering the transports. By enabling the fleet to concentrate in any ocean where the

British flag flies, the base puts a sound brick into the structure of Imperial defence; but if any government ever tried to use it for a forward aggressive policy, economic laws, which are more powerful than Cabinet decisions, would put an end to the project.

Before any estimate can be made of the part which the base at Singapore would play in the defence of the Far Eastern trade route, it is necessary to determine to what kind of attack the route could be subjected. The experiences of the great war proved that distant communications could be attacked in two ways. First, trade could be dislocated by fast cruisers like the Emden, with sufficient speed to appear suddenly off great ports of shipment, and to outdistance their pursuers; or, secondly, it could be disturbed by prolonged operations, undertaken by slow, specially-fitted raiders of the Moewe type, or by submarines. It can be said, at once, that operations of the first type will probably tend to disappear from naval war. The German light cruisers only raided British commerce in the first months of the war, because they could not get home. Light cruisers are so needed for fleet work, and purely military operations, that no naval power will ever be able to divert them for commerce raiding; they would be too easily lost, and are hard to replace.

Operations of the second type are, however, possible and even easy. Almost any naval power could fit out twenty merchantmen of the Moewe type, and fill their bunkers with coal; but, as has been said, slow vessels like these are bound to operate against the open trade routes. They cannot be sent against nodal points, guarded by fast cruisers, which can run them down. None the less, seeing how easily and with what immunity, the Moewe and the Wolf raided our communications in 1915, 1916 and 1917, it is reasonable to argue that provision should be made for putting the whole of the Far Eastern trade between Aden and Singapore under escort, should the need arise. The very great allocation of force which this would entail, the accumulations of shipping at the ports of departure, and the need of keeping those ports immune from attack, whilst the convoys were being collected, all prove that naval facilities at either end of the line should be developed by docks, repair basins, warship anchorages, and additional harbour facilities. Singapore, the most exposed end, must, obviously, come first.

THE LIMITS OF THE STEAM TURBINE.

IT is a commonplace that the enormous increase in the cost of fuel during the past dozen years has given a great impetus to the improvement of power-station practice. At the beginning of the century a steam rate of 19 lb. per kilowatt-hour constituted a record performance for a steam turbine. Little difficulty was, however, found in reducing this figure very substantially, and steam rates of 16, 14 and 12 lb. per kilowatt-hour were recorded in somewhat rapid succession, and some ten years ago a figure of about 10 lb. was ultimately attained. In the main, the improvement was effected by adopting higher and higher ratios of blade to steam speed. At the outset this procedure yielded substantial gains at no excessive increase in the cost of manufacture, but as in so many other departments of human endeavour, it is the last steps that cost. Each successive reduction of the steam rate became accordingly more and more expensive to realise. As matters stand, this consideration is not regarded so seriously to-day as it was under earlier conditions. Station engineers seem now prepared to face the cost of high-efficiency plant, and this has induced some builders to return to the use of low steam speeds at the high pressure end of the turbine, and to the original Parsons' plan of constructing the turbine with independent high-pressure and low-pressure units. Competent engineers have always recognised that there are some advantages attaching to both procedures, but so long as contracts were given to the lowest bidder, and penalties for failures to make guarantees good were either trivial or not enforced, it is not surprising that commercial considerations carried the day. On the Continent, indeed, there were not wanting certain "commercial engineers" who claimed that the single casing machine with uniform disc diameter was the best both thermo-dynamically and mechanically, as it was undoubtedly the cheapest to build.

As matters stand to-day, it is improbable that higher stage efficiencies will be reached in the future than the best already recorded. Designers will therefore aim at securing more uniform efficiencies throughout, and this is facilitated by the adoption of low steam speeds at the H.P. end, and by dividing-up the turbine between two or more casings. As usual, however, design has to be a compromise. What may be both technically and commercially feasible with a very large unit, may be undesirable from both points of view with a small one. There are moreover limitations arising from the physical properties of materials, and the discussion of these formed not the least valuable portion of the paper submitted on the 27th ult., by Professor A. L. Mellanby and Professor W. Kerr, to a meeting of the North-East Coast Institution of Engineers and Shipbuilders. We commence the publication of this important paper in another part of this issue. There has for some time past been a steady trend towards the adoption of higher and higher steam temperatures. The physical properties of our materials of construction must however fix a limit to this movement, and it is important to know at least approximately what this limit is. Our knowledge of the behaviour of steel at high temperatures has been most materially increased during the past two or three years, and engineers are indebted to Professor Mellanby and Professor Kerr for bringing together these important results, and for a promising attempt at co-ordinating them.

Experiments on the strength of steel at high temperatures are, of course, by no means new, but early ones failed to bring into prominence the extreme importance of the duration of the test. The experiments of Dickenson, quoted by the authors of the paper under review bring out this very clearly. They show that a steel which broke at a load of 8¼ tons per square inch at about 1,500 deg. F., in 6 seconds, failed under the same load in 28 hours, when the temperature was between 1,100 deg. F. and 1,200 deg. F., and in 956 hours at a temperature of about 1,000 deg. F., at which an ordinary breaking test would show a strength of about 20 tons per square inch. The importance of these observations cannot be over-rated. Professor Lea's experiments are also of great interest. These have shown that at 1,300 deg., the fatigue limit of a steel may be actually greater than its static breaking stress. This observation may well prove of great importance from the theoretical standpoint, but can hardly, we should think, find any application to practice. On a review of the data available, Professors Mellanby and Kerr suggest that 900 deg. F. may be taken as the upper limit of temperature now permissible in steam practice. This limit may conceivably be raised by advances in metallurgy and the remarkable alloys exhibited by Sir Robert Hadfield at Wembley last year, should undoubtedly undergo a thorough examination of their properties.

Adopting this temperature limit, the authors of the paper have made a careful study of the probable limit of pressure, and conclude that it will hardly pay to go beyond a pressure of about 1,250 lb. per square inch. With the limits of temperature and pressure stated, they estimate that in land-station practice it should be possible to develop one kilowatt-hour at the turbine shaft for an oil consumption in the furnaces of 0·37 lb. This figure, however, does not include what is required for auxiliaries, the addition of which would bring the oil rate up to 0·495 lb. per kilowatt-hour.

To attain these results it would, of course, be necessary to secure a boiler efficiency of some 90 per cent., but the trend of recent tests has been to indicate that this is not beyond the bounds of possibility. The authors of the paper also assume that the steam supplied at the stop valve, at a pressure of 1,250 lb. per square inch, will be withdrawn from the turbine and reheated to the initial temperature, in the first instance, when expanded down to a pressure of 500 lb. per square inch, and again when the pressure is reduced to 180 lb. per square inch. They also provide for progressive feed heating up to very nearly the boiler temperature, but do not deal with the difficult practical question as to how this is to be effected. There is, of course, no difficulty in efficient progressive feed heating up to the temperature at which the saturation line is crossed by the steam in its process of expansion. It is impracticable, however, to perform the operation in the same simple way with superheated steam. The latter will part with but little heat until it begins to condense, and hence cannot be used efficiently in a feed heater which gives satisfactory results with wet steam. A much more elaborate procedure would be necessary to secure progressive feed heating with steam which is bled from the turbine whilst still highly superheated.

The desired end could, however, be attained (theoretically, at least) by using this steam to drive a compressor into which was passed a mixture of steam and feed water at the temperature corresponding to that at which the saturation line is crossed. This mixture would be raised to the boiler temperature and pressure by the work of compression, and if the original proportions of water and steam were properly chosen, the steam would "at the end of the stroke" have all been condensed to water. There are obvious practical difficulties in carrying out such a scheme, but they are not necessarily insurmountable, and the authors were probably justified in assuming that it may prove practicable to adopt the progressive system of feed heating to nearly the boiler temperature.

Their final result is of great interest, and was arrived at only after a very careful, painstaking, and tedious study of the question as to the magnitude of the unavoidable losses. The time necessary to carry through work of this character can only be appreciated by those who have had to undertake similar studies.

The authors' estimated oil rate of 0·5 lb. per kilowatt-hour (inclusive of what is required for the auxiliaries) is at least as good as the most sanguine estimates of the possibilities of Diesel engines. In the tests made by the Marine Oil Engine Trials Committee of the Institution of Mechanical Engineers, an oil consumption of about 0·45 lb. per brake horse-power was realised, which would correspond to about 0·63 lb. of oil per kilowatt-hour. No doubt higher efficiencies than this have been recorded, but it is sufficiently evident that there is little chance of the Diesel engine replacing steam turbines in power station practice, if the estimates of Prof. Mellanby and Prof. Kerr can be even approximately realised.

Apart from questions of thermodynamic efficiency, the turbine has enormous advantages in the matter of output which, even under present conditions, prevent any general adoption of the Diesel engine in power stations in spite of the higher thermal efficiency of the latter in current practice. The superiority of the turbine over the reciprocator from the mechanical standpoint has, of course, long been recognised, and has led to many proposals for the construction of internal-combustion turbines. An interesting paper, containing a valuable résumé of the data now available on the progress, or perhaps we should say lack of progress, in this direction was read last Friday by Dr. T. B. Morley, before the Manchester Association of Engineers. In this paper, Dr. Morley also refers to a scheme which has been proposed several times during the past few years, viz., that of operating a turbine in a vacuum.

The plan is not so impracticable as it might at first sight appear, but the technical difficulties of realising anything like the efficiency theoretically possible are likely to be serious. The proposed cycle can, perhaps, be most easily followed by considering its application to a reciprocating engine. To simplify matters, it will be convenient to take the engine as single-acting, and to assume that a permanent vacuum is maintained below the pistons. Once such a vacuum is formed, its maintenance requires, at least theoretically, no expenditure of energy. Let 1 lb. of air be introduced above the

piston and heated at constant pressure, say, from 520 deg. F. absolute to, say, 2,500 deg. F. absolute. It will expand, doing work on the piston equal to about 104,740 ft.-lb. When the temperature attains the limit stated it is expanded adiabatically down to a temperature of, say, 1,500 deg., at which the corresponding pressure would be about 354 lb. per square foot. The work done in this expansion would be about 132,170 ft.-lb., making a total positive work of 236,910 ft.-lb. The return stroke is then commenced and conducted at constant pressure, heat being withdrawn during the process till the temperature of 520 deg. F. absolute is attained. It is then compressed isothermally to the atmospheric pressure of 2,116 lb. per square foot, and the cycle is then restarted. The negative work done on the return stroke is 101,020 ft.-lb., leaving the substantial balance of about 135,000 ft.-lb. of positive work. The cycle thus described is the theoretical one. In practice it would probably be desirable to work with a lower initial temperature. The turbine efficiency would probably hardly exceed 70 per cent. as a maximum, and the combined efficiency of the turbine and the compressor would not be more than, say, 56 per cent. There would be a corresponding reduction in the positive work done, and a large increase in the negative work. On the other hand, regenerative working would be possible, the air entering the cylinder being passed through the cooler in the opposite direction to the gases discharged.

THE MANUFACTURE OF TRAFFIC.

THE large orders for rolling stock that the railway companies of this country are putting in hand represent a provision, not made before it is due, for increasing the facilities of the freight and passenger services. Such increase must doubtless assist the growth of traffic, but the extent of this will necessarily be limited by the demands of industry. Though some signs of improvement are to be found, the state of industry is far from being sufficiently good to employ the manufacturing capacity of the country, especially in the engineering trades; and until we are again working at full capacity the traffic of the railways must be less than they could carry, and the prosperity of the whole country, of which railway traffics are so good an index, must suffer in proportion.

The circumstances of the time suggest, therefore, with more than usual point, the question whether the measures of re-equipment and extended equipment that the railway companies are taking are addressed as fully as they might be to creating the traffic on which the railway service lives and the whole country thrives. The question is of particular importance to the engineering trades, from which most of the companies' requirements have to be drawn. The immediate result of these measures is, of course, to provide a temporary mitigation of the unemployment in the trades concerned, but it is difficult to base on this a prospect of more permanent improvement, because in themselves the measures aim primarily at providing means of carrying traffic and not of creating it. The companies, nevertheless, have at least as great an interest in promoting the creation of traffic as they have in securing the means of carrying it, and this they have in common with the great engineering trades. It may be doubted, however, whether up to now this common interest has been properly considered by the parties concerned to the full extent that its importance deserves.

The gravest problem for both which has to be determined is how the large manufacturing energy involved in the current production of railway equipment can be best directed so as to increase to the utmost the volume of available trade. The solution of this problem is probably more important to both parties, and certainly is more important to the railway service, than the solution of the problems in which the companies and the industries have separate interests. Of these separate interests the most important relates to where the equipment is to be made. In some railway plants, if not in all, equipment is produced at least as cheaply as in industrial plants, and whatever profit manufacturers may make on their transactions with the companies must come out of the pockets of the companies. As against this separate interest, however, must be set the common one in the value of any increase of traffic to which the greater turnover of the industries may lead, beyond the carriage of the material used in filling the companies' orders. In some manufactures, moreover, the companies' shops may not be able to produce as cheaply as the industrial factories, and from time to time doubts seem to arise whether the specifications by which the quality of material is controlled are always enforced in them as strictly as they are in regard to manufacturers. To such direct saving as the companies may make in price, must also be added advantages they may gain in experience. Instances can be quoted of railway shops which in particular processes or even in an entire manufacture have made such use of their opportunities as to produce more efficiently than any private factories. Some part, of course, of this experience would be obtained in any event in running maintenance and repair shops, whether manufacture was undertaken or not. The cheapness with which standard parts can be produced owing to the existence of a regular repair organisation needing much similar work, tends to reduce the general cost of building new stock in companies' shops.

Facts such as these are among the commonplaces of the railway situation, but they seem to point to conclusions that are not generally recognised. Manufacturing for the railways is an important branch of most industries that undertake this class of work, but obviously these branches are less important than the industries as a whole. British railway business, such, for instance, as locomotive building, is similarly less important than the aggregate of British and overseas business. The importance of even the railway business that the industries of the country have at stake must, therefore, in any case, be greater than the mere volume of orders that British railway companies have to place; but in actual circumstances the real difference is still greater even than its apparent value. Up to limits that have not yet been reached in the railway industries of the country, the efficiency of manufacture varies partly with the size of the plant and partly—usually much more—with the extent to which it is worked to its full capacity and its proportionate overhead charges kept down. Industries that can work their plants up to their full capacity can thus produce cheaper and obtain a larger share of international business. The question of common interest to railway companies and manufacturers is, therefore, to what extent British manufacturers would be able to secure a larger share of world orders, if all or the bulk of British railway orders were pooled among the private shops and their overhead charges correspondingly reduced. An allied question is the extent to which private manufacturing facilities could be improved if manufacturers could look forward to a larger share of Home railway business.

These are questions that it is easier to ask in general terms than to answer in particular, but without prejudicing the answer, it may be permissible to suggest that some solution should be sought dispassionately by the common effort of the bodies who share with the country at large a common interest in them. It might doubtless be difficult for the proprietors and officers of some of the magnificent railway shops to be found in the country to consider with impartiality whether such shops should or should not supply the bulk of the requirements of their services. The attraction of *swadeshi* is not confined to India, and with more reason than can be found in the present state of Indian manufactures it may be asked whether the first care of a railway company in giving out its orders should not be to provide adequately for the fine shops in which it has invested its resources. Many considerations must be weighed before such a question can be answered, but what is certain is that no reliable answer can be found till these considerations have been weighed. It may be a matter, for example, of legitimate pride to a company to survey its wagon shops, to contrast them with those of average private factories, and to conjecture whether a more efficient manufacturing equipment for the purpose could be imagined. The utmost benefit that the company can derive from such shops is to get its wagons rather cheaper than it could buy them. If, on the other hand, it were so to use its orders and their influence as to induce private manufacturers to put in the superior equipment, it might not only be able to buy its wagons at within a little of the price at which it could make them, but might enable its suppliers to quote more favourably for oversea trade, and secure a sustained share of the world's orders, with the traffic they involve. Locomotives, tyres and axles, springs, steel work of all kinds, furnish analogous instances, in which orders placed by the companies in their own shops, even if they secure advantages in supply and first cost of the equipment, may do so at a disproportionate loss of business to the private industries and of traffic to themselves.

That answers to such questions cannot be given without taking careful account of the considerations involved is evident. Any answers, to be worth having, would require safeguards on the part of both parties, which could not be lightly given. A railway company could not place its supplies at the mercy of private enterprise without adequate assurance of obtaining them at reasonable prices and as required by the services they have to maintain. Manufacturers could not perfect equipment and reduce rates without reasonable certainty of consequent business. The bases of such arrangements involve more than mere negotiation, in which several parties seek to promote separate interests. They require close estimating, a broad view, and the recognition by each side of the difficulties and opportunities of the other side. To forecast the result of inquiries into matters so momentous before they have been fully made would be futile and presumptuous. What for the moment, however, seems clear is that the interests alike of the railway service and the engineering industries, with all that depends on them, call urgently for a fuller and more systematic examination than any yet made.

THE LEIPZIG FAIR.

To those who are familiar with the outlook of the organisers of exhibitions and industrial fairs in Great Britain, it is of interest to make comparisons with the long-established annual fairs of other countries. The Leipzig Fair, which was opened on Sunday last, affords a good, perhaps the best, example of what is done abroad. In this exhibition, scattered among at least 100 halls or separate buildings of many floors, are displays of almost every type of industrial product. Certainly most of the exhibits are of little interest to engineers, but there is an elaborate Technical Fair on the outskirts of the town to which 13 main buildings are devoted. In this section, there is much to interest engineers of every nationality, for the products of almost every engineering concern in Germany are exhibited, in addition to many from other countries. But of these only two are British. These far-seeing British firms are a cycle manufacturer and a tube company.

The opening of the Fair was overclouded by the news of the death of President Ebert, and consequently most of the spectacular display, which is usually made, was absent from this year's show. Traders from every part of the world crowded into Leipzig and the streets were dense with people going from one hall to another. For this year's Fair additional accommodation has been afforded by the opening of the Underground Fair Hall in front of the old Commercial Exchange. This is a building of reinforced concrete construction, with a roof flush with the pavement above. It is entered by stairways at the two ends of the market place. The height of the hall is 15 ft. and it is 270 ft. long and 140 ft. wide.

Turning to the Technical Fair, as has already been said, there are 13 separate main buildings in addition to an innumerable display in the open air by individual firms who make products, which are not injured by their presentation in this way. The lack of recognition of the potential value of the Leipzig Fair by British engineers must strike every visitor,

who looks into questions of engineering design and the construction of machines and the prices at which they are produced. In many cases it must be owned, though there is much to admire in the machines displayed in the halls of the Technical Fair, that British products at lower prices, of much better design, are available to perform the work done by these tools or plants. No one who makes the necessary endeavour to find out the prices at which these machines are offered for sale and who can estimate or obtain information on their output can fail to be struck with their high cost. British firms considering any question relating to international trade should not neglect the opportunities that are afforded by the Leipzig Fair. It is not merely that trade could be done with Germany, which should it become great would always be at the mercy of the politician since it might be checked immediately by a heavy tariff, but representatives from almost every country of the world are in Leipzig, and business is being done in which British firms might have participated. While such an important means of getting into touch with people who know little of any type of machinery but German is neglected, it cannot be said that British firms are doing everything to sell their products to the extent to which their qualities merit.

Sufficient has been said to convince those interested in overseas trade that they must consider seriously the value of showing at future exhibitions in Leipzig, and not neglect them altogether, as is the case at present. The various British associations might do much worse than arrange joint displays of the products of their members. To-day there are signs of an attempt to multiply the number of foreign Fairs, and this must be reckoned with in arriving at decisions relating to the individual shows. The tendency is an unfortunate one, for while there is concentration of every type of industrial endeavour in a single fair in each country, the interest and the business resulting to the participating firms must be all the greater. In this respect little fear need be entertained of a weakening of interest in the Leipzig Fair, which over the long period of years it has been held has built up a reputation that is unique. No matter, then, how many other Fairs are established it must not be supposed that the interest in this one will be appreciably weakened.

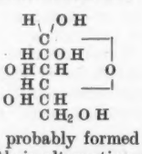
To give some idea of the nature of the exhibits, it may suffice, for the present, to refer to the classification of them within the individual halls of the Technical Fair, and leave for later the more detailed consideration of those items of most interest to engineering firms. In Hall 1 the display is of building materials and the requisite fittings for use in houses and works. Steel structures are exhibited, and examples of various types of building suited for different parts of the world. Stoves, central-heating appliances, and the various types of fire-grates are concentrated in Halls 2 and 3. Gas plant and instruments for use in connection with gas supply and distribution are shown in Hall 4. Electrical plant and agricultural machinery are a somewhat strange combination, but their display is arranged in the next section, as well as exhibits of the Oberschlesien Coke Works and the Chemical Factory Company, of Berlin. Hall 6 is devoted to vehicles and transport, but there are few motor-cars on show, as the German Association is very similar to the British one and limits exhibition to its own show, which is held in Berlin. Around this hall there is a variety of agricultural machinery. In succession, Halls 7 and 8 deal with the leather trades and the various uses of lignite. It is when Hall 9 is reached the main centre of interest to engineers is encountered, for here there is concentrated what is, perhaps, the finest display of continental machine tools that has ever been made. Later we hope to refer to many of these machines in detail. After Hall 10, devoted to electrical engineering, there is a further display of smaller machine tools, in addition to hand tools, welding and cutting apparatus, pumps, compressors, and blowers. Outside this is a show of commercial motor vehicles and conveying plant for various industries. The Iron and Steel Industry Association of Elberfeld occupy Hall 12; and machinery for special purposes, such as textile manufacturing, printing, the treatment of steel and chemical engineering plant, in Hall 13, complete one of the most complete exhibitions of engineering plant that has ever been got together.

(To be continued.)

NOTES.

THE CONSTITUTION OF SUGARS.

IN his Royal Institution discourse of last Friday on "Sugars from the Standpoint of the Organic Chemist," Principal Sir James C. Irvine limited himself to the constitutional problems which he has studied for years at St. Andrews, and which now, a hundred years after Faraday started such work, begin to look hopeful. The chemist is acquainted with a number of sugars, which by their names betray that they are only a group of the large family of the carbohydrates. Polysaccharides, cellulose and starch, &c., of the formula $(C_{10}H_{10}O_5)_x$, where the x remains unknown, are produced in plants. Disaccharides, $C_{12}H_{22}O_{11}$, comprising cane sugar and maltose, occur also in the animal system. Monosaccharides $C_6H_{12}O_6$, glucose, &c., very common in fruits, are the compounds from which the chemist tries to work his way upward. Whether or not glucose is produced from atmospheric carbon dioxide *via* formaldehyde is not quite settled yet. According to Professor Irvine, the constitution of the glucose molecule would be:



The C atoms probably formed a chain, with the H and OH on their alternating sides, and the one oxygen atom seemed to be loosely joining the first and fourth carbon atoms. The chemical behaviour of the glucose depended mainly upon the OH hydroxyl groups. In order to differentiate between these, the H in the OH had been substituted, first by the methyl group CH_3. It was then found that the upper OH (of the first C) was most easily methylated and oxidised; the others were subsequently attacked and methylated, and the pentamethyl glucose was no longer a sweetish, crystalline sugar, but a mobile liquid tasting like a liqueur. To methylate the second and third OH (independent of the first) had required a good deal of juggling and two years of study. Junctions of two molecules of glucose or its derivatives and the formation of polysaccharides took place at the fourth and fifth carbons and involved loss of the elements of water, H_2O. When the glucose chain closed upon itself, water was also lost and an anhydride formed. It had long been believed that compounds of the cellulose type formed long chains of glucose molecules; but the molecules might unite by polymerisation, and recent researches indicated that the saccharides were built up of bricks of three molecules. On the other hand, cellulose broke down by hydrolysis successively into dextrine, cellobiose and, finally, glucose; by interrupting the hydrolysis before the dextrine stage, compounds of three molecules had been prepared. Though the actual synthesis of polysaccharides had not yet been accomplished, Amé Pictet, in Geneva, and Professor Irvine, working independently, had quite recently succeeded in preparing glucosan, coming very near a synthetic starch. But the reverse process, conversion of glucosan into glucose, had so far failed, and we were quite ignorant yet as to the ways in which Nature produced saccharides without the aid of vacua, high temperatures and violent reactions. The optical activity of sugars (rotation of the plane of polarisation) was also unexplained. The spiral arrangement of the OH groups might, we venture to suggest, possibly account for that activity.

THE IDEAL HOME EXHIBITION.

With the housing question one of the most prominent among Home affairs, the now annual exhibition organised by the *Daily Mail*, may safely be expected to attract a large amount of attention. The "Ideal Home" exhibition opened on Monday last, at Olympia, and remains open until March 25. This year the exhibition would appear to be supported by the industries to an even greater extent than formerly, for the whole of the main hall, with its gallery, is well occupied and the new annexe, with its gallery, is also well filled. The old annexe is again occupied by gardens. The centre of the ground floor of the new annexe is occupied by a number of small houses, among which two stand out as of exceptional interest owing to the publicity recently given to the methods of construction adopted. One of the examples we refer to consists of a pair of Braithwaite steel houses, of the type we illustrated in our last issue, pp. 256, 257 *ante*. An inspection of this pair of houses will prove decidedly interesting. The material has been utilised in a very effective manner, and the interior is well planned. While naturally a departure which comes as something of a shock to our conservative natures, the example exhibited will go a good way towards discounting the condemnations indulged in by people who have not been able to realise the possibilities of such form of construction. An example of a concrete block house, having double walls, is also shown. This example is of more expensive design, but illustrates very well the possibilities of concrete for a low-price house of two sitting-rooms and three bedrooms. The outside finish is in concrete blocks which closely resemble ashlar of warm tone showing that this type of building need by no means be constructed of unattractive appearance. This exhibit is by the British Portland Cement Association of 20, Dartmouth-street, S.W.1. Messrs. Bivert and Firth, Cunard House, Cockspur-street, S.W.1, show a two-storeyed house constructed of factory-built sections on lines adopted in Canada. The method of construction enables houses to be assembled very rapidly. The interior may be finished with fire-resisting plaster either flush or inserted into the sections to obtain a panel effect. A number of other examples of small houses, bungalows, &c., are to be seen in which skilful planning and methods of construction make the most of limited room. The exhibition is wider in scope than formerly, but does not appear to be quite so closely restricted to the essentials of an ideal home. While this more general character may attract visitors, it is a question whether the trades mainly occupied in the structure and fitting up of small houses will benefit to a corresponding extent.

COUNTING THE ATOMS.

ON Saturday last, Sir Ernest Rutherford, F.R.S., delivered at the Royal Institution, the first of a course of four lectures on counting the atoms. In these lectures he intended, he said, to give an account of the gradual growth of our knowledge of the masses and dimensions of the atoms, one result of which had been a direct verification of the atomic theory.

During the past 25 years a great variety of methods, based on very different physical phenomena, had, he said, been developed for estimating the number of molecules in a stated mass of matter. The study of the "Brownian" movements of minute particles suspended in liquids or in gases had afforded one estimate, besides giving a very convincing proof of the kinetic theory. By another method the number of the atoms was deduced from observations on the blue of the sky, and a study of the distribution of energy in "black body" radiation provided another estimate, whilst last but not least was a method depending upon the measurement of the charge associated with an electron. The foregoing all provided means for counting the atoms, but during the past 15 years methods had also been developed for "seeing the atoms," or rather for seeing the effects produced by single atoms in certain special cases, thus affording a simple and direct proof of the atomic theory. It was also possible to follow the track of an individual α particle or of an electron through a gas. It was not his intention to go into the very difficult and elaborate question of the structure of atoms and molecules, though incidentally he might discuss how these latest conceptions fitted in with the results of the investigations already referred to.

An atomic theory as to the constitution of

matter was put forward by the Greeks some 2,500 years ago, but from the scientific standpoint the theory dated from its use by Dalton, to explain the combination of elements in multiple proportions. The general idea had been previously familiar. Newton had, in fact, discussed the hypothesis, and Boyle had expressed the view that a gas consisted of atoms of matter in constant movement. Dalton, however, applied the theory to co-ordinate a very definite series of facts which chemistry had collected at the time. For its complete development it was necessary to supplement Dalton's theory by Avogadro's hypothesis published in 1811. This hypothesis was an able, but in a sense, natural interpretation of the fact that gases combined in multiple proportions. On the basis thus afforded the great superstructure of modern chemistry had been reared. Chemists had isolated about 80 different elements, and had determined their atomic weights with great precision, and in organic chemistry there had been an enormous development of our knowledge as to how atoms held together. The basis of all this was, as stated, the atomic theory, but although this theory was generally accepted by chemists it was not philosophically necessary to them, and until very recently chemists felt no need for information as to the size and structure of the atom. All they needed to know was that the atoms of each element were alike, and that the atoms had certain powers of combination.

Nevertheless it was early recognised that it would be interesting to see if we could form some idea as to the number of atoms comprised in the smallest amount of matter we could weigh. The first attempts were based on a process of dilution. One milligramme of some strongly coloured substance such as rosaniline was dissolved in a litre of water, to which it gave a distinctive colour. One cubic centimetre of this solution was then transferred to another litre of water, and the process repeated until no trace of the characteristic colour could be found. It was thus established that the tint was still perceptible when the weight of the rosaniline was only $\frac{1}{100,000,000}$ of the water in which it was dissolved. The estimates of atomic dimensions formed on this basis were, however, much too large. Bunsen and Kirchoff next determined the smallest amount of sodium which would tinge a colourless flame. They found that they could detect $\frac{1}{300,000,000}$ of a milligramme, and hence this weight must consist of a large number of atoms. The discovery of radio-activity had made it possible to carry this process of "dilution" much further. Thus, if a wire were exposed to the radium emanation we got on it a deposit of Ra.A, Ra.B., and Ra.C We could calculate the amount of radium C which, deposited on 1 sq. cm. would be in equilibrium with the emanation from 1 mg. of radium. The amount was 2×10^{-11} of a gramme. This was an extraordinarily small quantity, and was in fact insufficient to form a continuous molecular layer on the surface. Its radioactivity was, however, still enormous in comparison with what it was possible to detect. If, for example, the wire were drawn over a newspaper, thus rubbing off a few molecules, say 1 in 10,000 of those on the wire, the paper would rapidly discharge an electroscope when brought near it. The amount on the paper was of the order of 10^{-16} grammes, but with care it was found possible to detect effects due to 10^{-20} grammes, but in this case the action was unsteady, showing that this quantity was comparable with the mass of the molecule.

Other methods of forming an estimate of molecular dimensions were based on the production of thin films of metals or liquids. Faraday had produced films of gold only about 6×10^{-7} cm. thick. These films were, however, quite coherent, though the thinnest showed green by transmitted light. These films proved that the molecule must be less than 10^{-7} cm. in diameter. In other cases, the thickness of soap films had been determined. If such a soap film were formed on a ring of wire and allowed to drain whilst examined by transmitted light, interference phenomena were observed. As the film thinned, however, by drainage or evaporation, a black spot appeared on it, which meant that the film was there too thin to reflect light. Its thickness, in fact, must then be less than a quarter of a wave-length. In this way it had been found that the thickness of this black spot was less than $\frac{1}{1,000,000}$ of a centimetre. The film was, however, still perfectly coherent, and the surface tension had its normal value, so that it was probably some 10 to 50 molecules thick. In this way, it was shown that the molecular diameter was certainly less than 10^{-6} cm., and probably less than 10^{-7} cm. In another method, studied by the late Lord Rayleigh, a film of oil was spread on water, displacing lycopodium, previously scattered on the surface. By appropriate methods, the weight of the oil could be determined, and the area covered by it could be measured. Lord Rayleigh had thus shown that the thickness of the film was less than 10^{-7} cm. These experiments had been discussed by Kelvin in his Baltimore lectures, and he then expressed the opinion that an eye, gifted with microscopic powers sufficient to perceive individual molecules, would see the molecules in the film lying at certain distances apart, and that in no part would the film be more than one molecule thick. This conclusion had been confirmed by

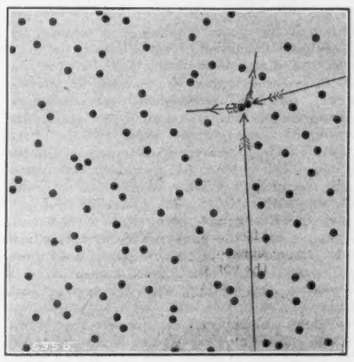


FIG. 1.

Langmuir, who from his observations, had been able to estimate the size and the number of the molecules in a given weight.

The methods described above, fixed, the lecturer proceeded, an upper limit to the size of the molecules. What was wanted in addition was a method fixing a lower limit to the size. The first estimate of this kind had been made by Young in 1802–03, in which he discussed the cohesion of liquids. Young was a man far ahead of his age. Independently of Laplace and partly in anticipation of him, Young had developed quite clear notions that surface tension was due to a powerful attractive force between the molecules. In one respect his views were clearer than those of Laplace, as he recognised that for equilibrium, this attractive force must change to a repulsive one when the distance between the molecules was sufficiently small. Laplace had established his own results by a great wealth of mathematical analysis; Young arrived at equivalent conclusions in a few lines of physical argument.

Young recognised that the cohesion of liquids must be connected with their surface tensions. He noted that a liquid surface could be formed in two ways. It was conceivable that we might pull apart a column of liquid of unit cross-section, thus forming two units of surface at the plane of separation, or we might alternatively form two units of surface by stretching a surface already in existence. In pulling the column of liquid apart, work had to be done against the cohesive forces, which, however, were sensible only over a limited range. Young assumed that averaged over the distance through which the cohesion was sensible, the force would have about two-thirds of its maximum value, so that denoting by k this maximum value, and by A the range over which the cohesion was sensible, the work done in forming one unit of surface was $\frac{A\,k}{3}$. A unit of free surface could also be formed, as already stated, by extending an already existing free surface against the surface tension.

The latter Young knew to have for water the value of about 3 grains per linear inch. He then equated the work done in forming a square inch of surface by the two processes described, getting the equation $T = \frac{A\,k}{3}$, where T denoted the surface tension. If, then, an estimate could be formed as to the value of k, A could be deduced from measurements of surface tension. Young concluded that the value of k must be of the same order for water as it was for steel, and he took the latter as being 23,000 atmospheres. He thus deduced that the value of A was about 10^{-7} cm. and, reviewing the whole procedure, expressed the opinion that the residual errors in his hypotheses were so small that future investigations would not materially change it. This estimate of Young's would, Sir Ernest Rutherford said, be accepted to-day. Young proceeded further to make an estimate of molecular dimensions, but being unacquainted with the kinetic theory of gases, he arrived at too small a value, viz., 10^{-10} in.

The question of fixing a lower limit to the size of the molecules had greatly interested Lord Kelvin, who had published in 1883 an estimate based on the stretching of a soap film. In stretching a soap film, work has to be done against the surface tension; but if the temperature of the film were to be maintained constant it was also necessary to supply heat during the process. At 27 deg. C. the work done in forming 1 sq. cm. of film was 72 ergs, but, at the same time, to maintain the temperature, further energy to the amount of 36 ergs per square centimetre must be supplied, making a total of 108. Now, the area into which 1 c.c. of water could be drawn must have a limit. The work done in forming such a film could not be greater than if the molecules were all separated from each other, as happened when water was converted into steam. To evaporate one cubic centimetre of water the energy required was $4{\cdot}2 \times 10^7 \times 580$ ergs. Hence, denoting by A the limiting area of the film and assuming that each side of it would require 108 ergs of energy for its formation, Kelvin got the equation

$$2 \times 108 \times A = 4{\cdot}2 \times 10^7 \times 580.$$

He thus found A to be about 10^8 cm., so that a minimum limit to the molecular diameter was 10^{-8} cm. This figure was, Sir Ernest said, very nearly right.

The kinetic theory of gases, the lecturer continued, was old. It had been suggested by Bernoulli, and Waterston had put it forward in 1845. It had been held by Joule, who published the first calculation of molecular velocities. Its later development was the result of work of Clausius and Maxwell, carried out about fifty years ago. Subsequent refinements were due to Boltzman and to Jeans and Chapman in this country. An important stage was reached when Maxwell showed that the mean free path of a molecule could be calculated. The molecules of a gas, being in constant motion, were continually coming into collision with each other, and the mean free path was the average distance covered by a molecule between consecutive collisions. The chance of a hit depended in the first instance on the pressure (which was proportional to the number of molecules in a cubic centimetre), and secondly to the cross section of the molecules, which for simplicity were assumed to be spheres. Maxwell showed that this mean free path was connected with the size of the molecules by the equation

$$\lambda = \frac{0{\cdot}7}{N \pi D^2} \quad . \quad . \quad . \quad . \quad (1)$$

where λ denoted the mean free path, N the number of molecules in a cubic centimetre, and D the molecular diameter. He also showed that

$$\lambda = \frac{3\eta}{\rho \overline{V}}$$

where η is the coefficient of viscosity, ρ the density of a gas, and $\overline{V}$ the square root of the mean squared velocity of the molecules, which Joule had shown could be easily calculated from the pressure and volume of a gas. The value of this velocity for hydrogen was about 1,800 m. per second.

From this second equation λ could be calculated,

and from equation (1) ND^2 found. To get a limiting value for D the rough assumption was made that a liquid consisted of spherical molecules in closest packing, so that $\frac{N D^3}{\sqrt{2}}$ represented the volume of 1 c.c. of gas condensed into a liquid or solid form. Combining this with the value found for ND^2, both the diameter of the molecule and the number in a cubic centimetre could be deduced. Maxwell thu found for N the value $1 \cdot 9 \times 10^{19}$. Meyer got $N = 6 \cdot 1 \times 10^{19}$, and the true value was now known to be $2 \cdot 70 \times 10^{19}$. Lord Kelvin had prepared the diagram reproduced in Fig. 1, which showed to scale, the size and spacing of atoms in a cross section of a cube of air measuring $0 \cdot 64 \times 10^{-6}$ cm. across.

From Maxwell's expression for λ in terms of the viscosity it appeared that the viscosity of a gas should be independent of the pressure; since if ρ were halved, λ would at the same time be doubled; and since η depended on the ratio of the two, it should be independent of the pressure. This was a surprising and unanticipated conclusion, but had been proved to hold good for a range of pressures from about 1 mm. of mercury up to 760. This experimental verification, made in the first instance by Maxwell, led to the belief that the kinetic theory was probably correct.

The method of deducing N and D from the kinetic theory was not very accurate, giving only approximate results, but the estimates made were in rough general agreement with those derived by other methods.

LARGE POWER-STATION DEVELOPMENTS.

THE equipment and rapid growth of high-powered stations for the supply of electrical energy on a large scale was strikingly illustrated in the course of the lecture entitled "A Visit to America," delivered before the Graduates' Section of the Institution of Mechanical Engineers, by Mr. W. H. Patchell, Past President, on March 2. The address was based mainly on the 120,000-volt transmission system of the Detroit Edison Company, which extends, broadly, overland from Lake Erie to Lake St. Claire. A very wide selection of lantern slides assisted in making clear the lay-out of the different stations, such as Trenton Channel, on the system referred to, although relatively distant stations such as Cahokia, at St. Louis, and the Windsor Power-station, on the Ohio River, were also described.

That the high-power station was justified, in general, in these localities could be realised from the fact that on a 13-minute rating 333,400 kw.-hours had been metered with a load factor of 63·4 per cent. The Trenton Channel station is situated on an island in the southern part of Detroit River, and is equipped with 50,000-kw. units housed in a building 340 ft. long and 140 ft. wide. The boiler-house is 248 ft. long, 137 ft. wide and 140 ft. high, and eight units are installed having a working pressure of 415 lb. per square inch and supplying steam at a temperature of 707 deg. F. Water-lined furnace walls are used. Economisers were not originally specified in the design, but the area of these now in use totals 18,900 sq. ft. The rating was 100,000 lb. per hour, but 350,000 lb. per hour has been accomplished and could be maintained indefinitely. Coal is pulverised by means of a Bradford breaker, 30 ft. long and 11 ft. in diameter, from which the fuel passes into a hopper, thence by means of an elevator into a dryer, the ground coal being drawn away by an exhauster and fanned into a "cyclone," whence a screw conveyor removes it to a storage bin. The material finally passes through a feeder to the burners on the boilers. There are two burners to each feeder, two feeders to each dryer, and 16 burners to each boiler. The volume of the furnace is 25,140 cub. ft.

In the latest 50,000-kw. turbine installed—a 21-stage Curtis—the working speed is 1,200 r.p.m., the steam pressure 400 lb. per square inch, and the temperature 707 deg. F., the 14th, 17th, and 19th stages being bled. Direct-current motors were used for the auxiliaries. The turbo-generator is 60 ft. long. This arrangement is typical of the latest practice. With regard to switchgear, each 50,000-kw. turbo-generator is provided with three auto-transformers. Switching takes place at 13,000 volts, push-buttons operating the switches.

The Lake Cie station, at Milwaukee, was then described, in connection with which a Babcock boiler, built in the year 1923, is stated to have obtained an operating efficiency of 80 per cent. The attainment of 88·3 per cent. was claimed at the Windsor station—a figure exceeded, however, by the 92·7 per cent. overall efficiency registered at Hell Gate station. The Windsor station afforded an example of John Anderson's method of providing an air chamber for the bottom of the boiler, adopted in conjunction with double furnace walls and a water screen. The doors were worked simultaneously by manual power, and this was the first arrangement to make good on pulverised coal. The Hell Gate station was an example of the successful application of the underfeed stoker. On the Fall River station, near Boston, two 30,000-kw. machines, working at 300 lb. per square inch, were installed. The lecture concluded with the illustration of the forging of a boiler drum of 88,475 lb. weight, 34 ft. long, 4½ in. thick in the body, 4 ft. in diameter, and 9 in. thick at the end.

95-TON ANVIL BLOCK.

Although the present position of foundry practice and equipment imposes a certain limit to the maximum weight and dimensions of the castings produced, this limit is being extended from time to time as the necessity for some particularly heavy casting arises. An instance of this is afforded by an anvil block weighing 95 tons recently made by the Brightside Foundry and Engineering Company, Limited, of Sheffield. The pattern for the block was constructed at the company's Wicker Works. The mould was built up with bricks and composition loam, and several building rings were used in the course of the work. After the pattern had been withdrawn the mould was sleeked, blacked, finished and thoroughly dried, when the cores were placed in position. The cope was located and secured, when the space between the outside of the mould and the sides of the pit was rammed up, care being taken to ensure that lateral pressure was resisted. Two runners leading to the bottom were used, one at each side of the mould, while another from the stand ladle was cut in about a third of the way up. To obtain the requisite amount of metal, four cupolas and two air furnaces were kept blowing continuously. These cupolas had a capacity of 28 tons of metal per hour, and approximately three hours were required to secure the quantity needed. Casting commenced at 10 a.m., and within 4½ minutes the cast was through the riser. A stand ladle of 42 tons capacity was used, together with one 23-ton and two 17-ton ladles. Feeding the casting required 30 hours, and this was followed by leaving the block in the pit for a fortnight, when it was removed by a 120-ton crane.

CONTRACTS.—The Bradley Pulverizer Company, 37, Walbrook, E.C. 4, have secured an order from the Poplar Borough Council Electricity Works for the supply of a Bradley three-roll closed-type mill for preparing pulverised coal fuel for boiler firing in connection with plant now being installed at the Poplar Power Station.—The Sperry Gyroscope Company, Limited, of 15, Victoria-street, London, S.W.1, have supplied Sperry gyro compasses and repeaters to the Anchor-Donaldson liner Letitia, the Canadian Pacific Railway steamer Princess Marguerite, and the Hakusan Maru of the Nippon Yusen Kaisha. Recently equipped in addition with a Sperry gyro pilot, the latter ship is the first Japanese vessel to possess automatic steering apparatus.

MARINE ENGINEERS AND SHIP SURVEYORS.—The Society of Consulting Marine Engineers and Ship Surveyors held its fifth annual dinner on Thursday, February 26, in the Connaught Rooms, London, when Mr. H. E. J. Camps presided over a company of about 400, amongst whom were many distinguished members of the Admiralty bar. The Society, though a young one, has, through the establishment of a high standard of entrance qualification and the formulation of a code of professional conduct for its members, obtained for those associated with it recognition by the shipowners of the world, as the authorities to deal with all the vexed questions regarding the seaworthiness of vessels and the state of a ship's propulsion machinery. This was evident from the speech of the President who, in replying for "The Society" contended that, had this professional body been established before the European War and their present reputation been then won, the taxpayers might have been saved enormous sums in dealing with the mercantile vessels under the Government control.

LETTERS TO THE EDITOR.

BRITISH MACHINE TOOLS AT EXHIBITIONS.

TO THE EDITOR OF ENGINEERING.

Sir,—May I briefly reply to the letter from "M.I.Mech.E." in your issue of the 20th inst. The Machine Tool Trades Association was formed not primarily for the purpose of promoting exhibitions but for the opposite purpose of restricting the too numerous exhibitions which were being promoted before its formation.

Yours faithfully,
HERBERT G. WILLIAMS,
Secretary, Machine Tool Trades Association.
London, February 27, 1925.

ANTI-FRICTION BEARINGS FOR HEAVY DUTY.

TO THE EDITOR OF ENGINEERING.

Sir,—I note that in your issue of February 20, Mr. H. T. Newbigin, Technical Director of Michell Bearings, Limited, refers to the remarks made by Mr. D. B. Spittle at the discussion on my paper at the Institution of Mechanical Engineers. In the last paragraph of this letter, it is stated that numerous enquiries have been received by them to convert existing mills *fitted with roller bearings* to the Michell system. The conclusion is also drawn from this that the roller bearings leave something to be desired.

As I think this paragraph may be misleading, I would like to state that, so far as the bearings referred to in the paper are concerned, only two firms in this country have as yet taken advantage of these designs, and the complete history of these applications is given in the paper. Further, the experience with them, it is to be noted, has been quite satisfactory.

The other mills on which the bearings have been fitted are on the Continent and the experience there has also been given completely in the paper.

Some of the mills so fitted were considered, in the first instance, as experimental, and the development of the principle to further mills was the outcome of the satisfactory experience obtained.

Yours faithfully,
THE SKEFKO BALL BEARING COMPANY, LTD.,
B. F. DAHLERUS, Managing Director.
Luton, February 27, 1925.

PREVENTION OF CORROSION.

TO THE EDITOR OF ENGINEERING.

Sir,—In your issue of February 20, Mr. J. Vernon Shaw suggests that the corrosion of metals could be overcome by maintaining the hydrion concentration at a suitable value through the addition of a "buffer" to the water which is causing the trouble. He bases his argument on the assumption that the corrosion rate is proportional to the hydrion concentration. This assumption is contrary to the experimentally determined facts. The researches of Whitman and Russell (J. Soc. Chem. Ind. 43 (1924) 193 T) indicate that, in the "submerged corrosion" of iron by natural waters, the rate of attack is *almost independent of the hydrion concentration* within the limits P_H 4·5 to P_H 9·5, but is determined mainly by the rate of supply of oxygen, which is required in the electrochemical reactions involved. Since nearly all natural waters fall between these limits, the addition of buffers would usually have but little effect; the sounder method of preventing corrosion would seem to consist in removing the dissolved oxygen. Those interested should refer to the instructive curves given on page 194 T of Whitman and Russell's paper. I would merely add the comment that, although the *supply* of oxygen determines the *total corrosion*, it is the *distribution* of oxygen which determines the *damage* produced; for the corrosion tends to become concentrated in crannies and other points relatively deficient in oxygen, which become anodic to the aerated portions, as was pointed out in a paper read before the Institute of Metals in 1923. (U. R. Evans, J. Inst. Met. 30 (1923) 239, especially p. 279).

It is true that in liquids on the acid side of P_H 4·5, which can liberate hydrogen as a gas from iron even in the absence of dissolved oxygen, the corrosion rate does increase quickly with the hydrion concentration; here it is necessary to neutralise the free acid, although there are many cheaper and more effective ways of doing this than by the use of buffers. Again, in liquids on the alkaline side of P_H 9·5, the corrosion rate falls off with increasing alkalinity, and advantage of this fact is taken by those engineers who dose their waters with alkali in excess of that needed for softening purposes, and thus decrease the total corrosion within their plants. In this sense, hydrion regulation has already been practised for many years, but the pro-

tective action of the alkali really depends on the formation of an insoluble film. For that reason, the method may, under certain circumstances, be dangerous, especially with waters of high chloride-concentration, since, if the protective film should break down at one particular place, the corrosion which might otherwise be distributed over the whole surface will be concentrated on the site of the failure and perforation may quickly occur. This question of the local breakdown of the protective film produced by alkalis was investigated in a research published by me last year (J. Soc. Chem. Ind. 43 (1924) 315 T, especially p. 318 T); subsequent work, which will be published shortly, has indicated that the breakdown occurs especially easily at the water-line.

It would therefore appear that the removal of oxygen is a safer method of preventing corrosion than dosage with alkalis. Incidentally alkaline liquids may often be objectionable in other ways; recent work at the Massachusetts Institute of Technology, for instance, supports the view that the intergranular cracking of boiler-plates is mainly due to alkali in the feed-water.

Yours, &c.,

ULICK R. EVANS.

Department of Chemistry, Cambridge University, February 26, 1925.

LABOUR NOTES.

WHILE in Germany last week-end, Mr. J. T. Brownlie, President of the Amalgamated Engineering Union and Secretary of the British Section of the International Metalworkers' Federation, addressed large gatherings of metalworkers. At mass meetings in Frankfort and Cologne respectively, between 6,000 and 7,000 engineers, steel smelters, and blast furnacemen attended, and an international conference held at Cologne on Sunday and Monday was composed of 126 delegates, representing 13 countries. Mr. Brownlie spoke at all the gatherings, and in his speeches he emphasised the point that questions of wages and hours were not national but international, as the leading manufacturing countries were competitors in practically the same markets, and if one country enjoyed more favourable labour conditions than another, the other was obliged to use the fact as a reason for depressing his own. The present wages demand in Great Britain was, he added, a case in point. The long hours worked by, and the low wages paid to, German metal workers were being cited by British employers as reasons why the demand of the workers for increased wages could not be paid, and British trade unionists were looking to their fellows in Germany to see that arguments along that line ceased, as soon as possible, to have any foundation.

The Ministry of Labour states that the number of unemployed persons on the registers of Employment Exchanges in Great Britain on February 23, 1925, was 1,236,200. Of these 945,100 were men, 34,600 boys, 223,900 women, and 32,600 girls. On February 16, 1925, the number was 1,239,796, or 943,088 men, 35,323 boys, 227,703 women, and 33,682 girls; and on February 25, 1924, it was 1,154,504—849,800 men, 35,989 boys, 233,104 women, and 35,611 girls.

The linking up of the activities of the Trades Union Congress General Council with those of the local Trades and Labour Councils may be regarded as partly a progressive step and partly a protective measure. It is progressive in the sense that through the new organisation the General Council—which is, in effect, the executive of the Trades Union Congress—will be able to co-ordinate local with national activities according to the policy formulated yearly by Congress. Until this change was decided upon, the General Council's touch, like that of Congress itself, was with the central authorities of the affiliated unions. Now, it will be in touch as well with the rank and file through their representatives on the local Trades and Labour Councils. Whether the reorganisation will promote efficiency or otherwise, remains to be seen; but it should have the effect of improving the representative character of the local representative bodies.

The change has been described as partly a protective measure because the Communists, working through the National Minority Movement, have for many months been striving assiduously to capture the movement through the Trades and Labour Councils. They have "worked" the branches with the object of securing election to the local representative councils of suitable candidates, and largely owing to the indifference of the majority of the rank and file have achieved a certain degree of success. At a recent Trades Union Congress a proposal, which was ascribed to them, was submitted to admit Trades and Labour Councils to affiliation, but it was turned down on the ground that as the trade unions whose branches had elected the local councils were already affiliated, acceptance of the resolution would have the effect of duplicating representation. The National Minority Movement is still, of course, working to achieve its purpose, but the probability is that, as this new move of the General Council develops, its chances of success will appreciably diminish.

At the moment of writing no news was available as to what took place at yesterday's further meeting in London of representatives of the coalowners and the executive of the Miners' Federation of Great Britain to consider the position of the industry. After considerable discussion, the Blackpool delegate conference of the Miners' Federation unanimously adopted the following resolution:—"That this conference, having considered the various proposals submitted by the districts relating to the National Wages Agreement and a report by the Executive Committee respecting the proposed further investigations, decided to remit to the districts the full list of proposals, and that the executive continue their investigations and report to a further conference at as early a date as possible."

It is stated to be the intention of the executive to keep the districts fully informed of the progress of their investigations into the wage position, and it is proposed to do this by calling the delegate conference together at intervals of about a month until a stage has been reached when a definite decision can be taken as to whether notice shall be given in June to end the agreement. The delegate conference will also be called upon finally to approve the national wage proposals when they have been welded together in one comprehensive programme.

The delegate conference also decided unanimously to ask the Labour Party to embody in the Miners' Minimum Wage Act Amendment Bill certain definite amounts, and these may be taken as an indication of the wage the Federation is aiming at. It was resolved that the following should be inserted in the measure: "An adult day-wage worker to be paid a minimum of not less than 11*s*. a day and an adult piece worker not less than 12*s*. a day, and an adult surface worker not less than 10*s*. a day." There was some difference of opinion as to the tactics to be employed. A section urged that Parliamentary action for a new minimum wage under existing conditions was bound to be futile and that it might jeopardise the negotiations in the industrial sphere. It was, however, decided that the Federation should give unqualified support to the Labour Party's Bill, and that at the same time the executive should proceed with their inquiries and the preparation of the general demands for a new or revised agreement in readiness for negotiations with the owners.

A number of awards affecting the wages of men employed in the Royal Dockyards and other Admiralty establishments have been issued by the Industrial Court. On a claim by the men that the maximum rate of skilled labourers in the rigging shops in Home dockyards should be increased to 46*s*. per week plus bonus (at present 14*s*. per week) the Court decided that no alteration should be made. A similar finding was arrived at in respect of the application that the maximum rate for hammermen in Home dockyards should be increased from 44*s*. to 46*s*. per week plus bonus (at present 14*s*. per week).

For motor drivers and mates employed in Home dockyards claims were submitted for basic rates of 47*s*. and 44*s*. a week respectively, plus a bonus of 14*s*. in each case. In their decision on these claims the Court state:—"The Admiralty dockyards may be regarded as self-contained, and the rates of pay and conditions of service prevailing in the dockyards are of a definite character as belonging to a well-defined industry. While, in adjusting rates of pay and conditions of service, due regard must be had to the rates paid in outside industries and trades, regard must also be had to the scheme under which the work in the dockyards has been sectionalised and built up and under which the relative position of the various classes of employees, including motor drivers and drivers' mates, have been duly taken into account. The Court are not satisfied that a case has been made out for a readjustment at the present time of the relative position of, or maximum rates now paid to, motor drivers and drivers' mates. They, however, consider that the rates for motor drivers less than the maximum rate of 44*s*. per week should be readjusted with a minimum rate of 41*s*. per week, and decide that 50 per cent. or thereabouts of motor drivers should receive 41*s*. per week, 20 per cent. or thereabouts 42*s*. per week 15 per cent. or thereabouts 43*s*. per week, and 15 per cent. or thereabouts 44*s*. per week, in addition to which will be paid the cost-of-living bonus current from time to time. The selection of drivers to be paid the various rates will be determined in the same manner as heretofore. A case for the readjustment of the rate of the drivers' mates has not been made out."

The first meeting has taken place of the Welfare Supervisor's Association Joint Committee, the formation of which is claimed to be an important step forward in the industrial welfare movement. The new body is the outcome of a resolution passed at the 1924 conference on industrial welfare at Balliol College, Oxford, and it consists of two representatives each from Associations of Welfare Supervisors in London, Liverpool, Manchester, the Midlands, Scotland, South Wales and Yorkshire. The chair was taken at the opening meeting by Mr. C. Jackson-Shawe, the welfare officer of the Manchester Ship Canal. Three hundred welfare associations were represented. The work of the welfare supervisor, of whom it is estimated there are now over 1,000 employed in different industries, covers a very wide field, including methods of dealing with personnel, the maintenance of healthy working conditions, staff canteens and restaurants, first aid and accident prevention, education, and the many social and recreational activities which are now encouraged by progressive firms. It is anticipated that close co-operation between this Joint Committee and the Industrial Welfare Society will give a further impetus to a movement which is receiving active approval from every industry in the country.

The Moscow correspondent of the *Soviet Union Review* states that the pressing need for qualified workers in the oilfields of Baku has prompted the local administration to send twenty operatives to the United States in order that they may study the methods of work employed in the American oil industry. It is proposed, he adds, that the workers shall remain in the United States for twelve months.

In a written reply to Mr. Merriman, who asked what were the total receipts from unemployment contributions, the expenditure on unemployment benefits, and the average number of unemployed persons, Sir Arthur Steel-Maitland gives the following table:—

Insurance Year.	Contributions.	Benefit.	Average Number of Unemployed Insured Persons.
	£	£	
1917–18 ..	4,284,664	86,153	99,460
1918–19 ..	3,866,942	152,721	—
1919–20 ..	3,955,953	1,009,126	—
1920–21 ..	13,471,814	34,118,195	1,133,085
1921–22 ..	42,224,176	52,848,214	1,750,822
1922–23 ..	46,170,840	41,880,832	1,362,613
1923–24 ..	50,096,079	35,971,411	1,203,270

The Minister adds that complete figures are not available for the years 1918-19 and 1919-20. Until December, 1919, the rate of unemployment benefit was 7*s*. a week, and from December, 1919, to November, 1920, 11*s*. a week, with no allowance for dependants. The rates of contributions have varied considerably.

Speaking at the Working Men's College, St. Pancras, on Saturday, Mr. W. L. Hichens, chairman of Messrs. Cammell Laird and Co., Limited, said that the fundamental consideration in the industrial problem of this country to-day was our foreign trade. Our export trade must be maintained in order to pay for our imports, and the keynote of our industrial policy for many years to come must be how to maintain and expand it. Wages in this country at the present time could not be settled by the criterion of some ideal standard of living, but by consideration of the foreign market. We must be guided to a large extent by what our rivals were paying. The first essential was that our costs should be at least as low as those of our foreign competitors. The immediate outlook was not particularly satisfactory. We were faced with fierce international competition, in which the Germans, at any rate, were willing to accept a lower standard of living in order to get a larger volume of the world's trade. Our standard of living was, therefore, threatened, through no fault of our own, but partly because the wealth of the world was less than before the war, and partly because others were willing to accept a lower standard. Little could be done by Governments, but in the long run, Mr. Hichens said, the problem would have to be settled by the workers themselves.

On Wednesday this week, representatives of the engineering trade unions which have applied for a wages advance of 20*s*. per week, again discussed at a conference in London the policy to be followed in the negotiations with the employers. The official report given out at the close of the meeting stated

that reports had been received from the various executives, and that it had been decided to meet the employers on the following day and press for a definite reply to the wages application. What transpired at yesterday's conference with the representatives of the Engineering and Allied Employers National Federation was unknown at the time of writing; but if the unions' spokesmen have adhered to the decision to "press for a definite reply" and, in that indirect way, reject Sir Allan Smith's proposal of a revision of certain working conditions, the outlook may become disquieting.

It is stated that a provisional agreement has been arrived at by the executives of the Amalgamated Society of Woodworkers and the Shipwrights and Shipconstructors' Association, providing for interchangeability of members in certain defined circumstances. Where the number of house joiners in any area is insufficient it may be increased by the employment of shipwrights, who will be, for trade union purposes, under the jurisdiction of the local management committee of the woodworkers and conform with building trade rules and customs. Where there is a shortage of shipwrights in any area it may be made up by employing house joiners under similar conditions. The agreement also provides for the setting up of national and local machinery for the adjustment of demarcation differences. The members of both organisations are balloting on the proposals. If the vote is in favour, a further obligation by the Shipwrights' Association will become effective. This is to recognise the cards of members of the Woodworkers' Society, who seek employment as carpenters in seagoing ships, and to endeavour to secure representatives for them on the National Maritime Board.

At a meeting in Leytonstone on Wednesday, organised by the Leyton and Leytonstone Unemployed Workers' League, a resolution was passed pledging those present to form a Steel House Construction Trade Union. One of the speakers said that the promoters of the new organisation were not trying to break or to hurt the building trade unions. There were nine brickyards on the market within 40 miles of London, and still there was a shortage of material. Steel houses were something which the men could learn to build in a few weeks, and their scheme offered the men free education in the construction of the houses and payment of a certain amount of money while they were being trained.

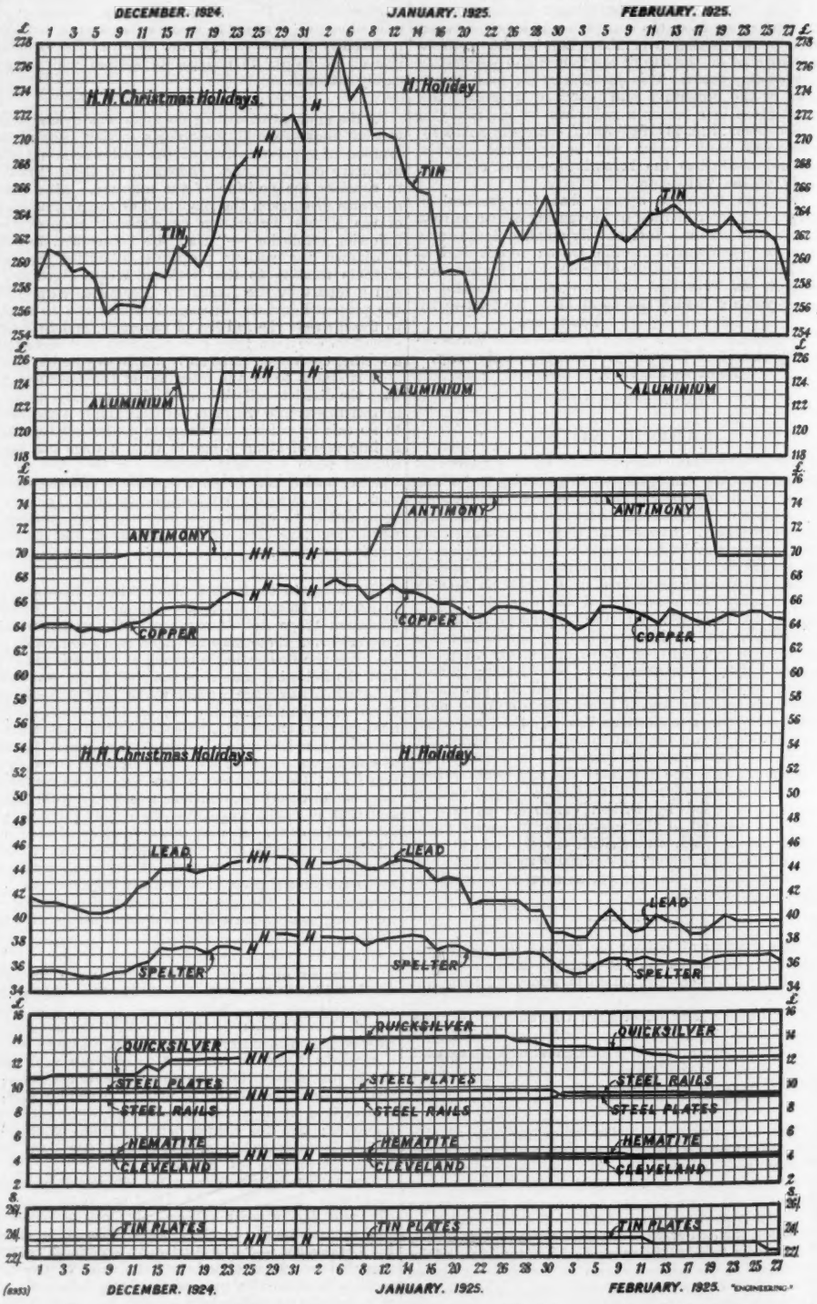
PERSONAL.—It is announced that Commander Charles Worthington Craven, R.N., special director in charge of the Vickers works at Barrow-in-Furness, has been elected to the Board of Directors of Messrs. Vickers Limited.—The address of the branch office in Scotland of the British Reinforced Concrete Engineering Company, Limited, is now 144, St. Vincent-street, Glasgow, C.2.

THE ILLUMINATING ENGINEERING SOCIETY.—On Tuesday, March 3, a visit was paid to the Waterloo Station of the Southern Railway Company by members of the Illuminating Engineering Society to observe the methods of lighting adopted at the station, and secure an opportunity of discussing the general problem of railway terminal lighting with the engineering staff of the company. Previous to the discussion several lantern slides were shown to illustrate recent practice. In the remarks which followed, several interesting points were brought out. For example, the necessity for a certain amount of upward directed light from any source, was evidenced by the visitors. On the other hand, the staff emphasised the need for simplicity of working in all lighting devices adopted. Mr. A. Cunnington, lighting engineer to the Southern Railway Company, described the Waterloo system, and replied to the questions which arose during the discussion which was opened by Mr. L. Gaster, Hon. Secretary to the Society.

THE OIL TANKER "INVERLAGO."—Recently launched from the Belfast yards of Messrs. Harland and Wolff, Limited, the petroleum carrier Inverlago is the first of four shallow-draught vessels being built for Messrs. Andrew Weir and Co., Limited, and intended for Venezuelan trade in the Gulf of Maracaibo. The ship is 315 ft. long and 50 ft. beam, with a gross tonnage of 2,360, and is being built to the requirements of Lloyd's highest class. Eight watertight bulkheads divide the vessel into compartments of which five are occupied by oil tanks. Possessing a straight stem and elliptical stern, the Inverlago will be rigged as a fore and aft schooner. The propelling machinery will consist of triple-expansion engines operating twin screws and developing 1,100 i.h.p.; steam will be generated in two cylindrical single-ended boilers working at 180 lb. per square inch pressure, each having three Morison furnaces fitted to burn oil fuel on White's system under natural draught. The condensers are of the circular type and the air, circulating, feed and bilge pumps are all worked from the main engine. Wireless equipment is fitted and a 40-ft. derrick for 2-ton lifts is arranged to work on either side of the mast, with a similar derrick amidships.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN THE PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates, are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of quicksilver is per bottle, the contents of which vary from 70 lb. to 80 lb. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

THE INSTITUTION OF STRUCTURAL ENGINEERS.—Since it has been found impossible for the Science Committee of the Institution of Structural Engineers to prepare the number of reports desirable on the many problems which confront the profession, it has been decided to form Sectional Committees from the Science Committee. Such bodies have already been organised to deal with (*a*) concrete and (*b*) steel; and among the subjects being dealt with are such questions as the adhesion of and friction between concrete and steel, reinforced concrete, piles, and the effects of sewage, oils and fats upon concrete. It is hoped that the sub-division of the science Committee will greatly facilitate the addition of many other subjects to those being studied by the Institution.

LIGHT-WEIGHT DUMPY LEVEL.

MESSRS. COOKE, TROUGHTON AND SIMMS, LIMITED, LONDON.

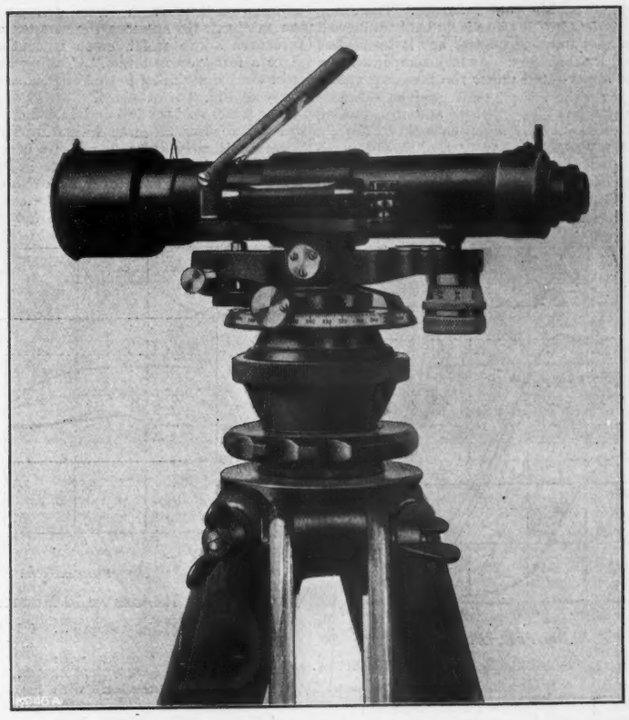


FIG. 1.

FIG. 2.

LIGHT-WEIGHT DUMPY LEVEL.

WE illustrate above a very compact form of level made by Messrs. Cooke, Troughton and Simms, Limited, of 3, Broadway, Westminster, to meet the demand for a more handy form of level than the ordinary 14-in. dumpy, and at the same time capable of somewhat greater accuracy. For the very highest class of work it is now usual to employ "precision" levels, and in our issue of June 3, 1921, we described an instrument of this type, constructed by Messrs. T. Cooke and Sons, one of the firms now constituting Messrs. Cooke, Troughton and Simms. The standard of such instruments is higher than is required for all but very special surveys. The instrument represented in Fig. 1 is capable of a higher class of work than the old standard 14-in. level, it requires less time in use, and has not more than one-fourth the bulk and weight. The essential characteristic is that the telescope is levelled for each observation. It is neither necessary, nor desirable, to spend time in getting the base of the instrument accurately horizontal. For rough levelling the instrument is provided with a ball and socket head at its base, and in "setting up" the levelling is effected by simply moving the head by hand so as to bring to its centre the bubble of a small circular level. This done, the joint is clamped solid by the milled edge shown a little below the horizontal circle in Fig. 1. In taking an observation the telescope is directed to the target or staff by means of a pair of sights fixed on top of the telescope, as shown. The telescope is then accurately levelled by the micrometer head shown below the telescope near the eyepiece, and a fraction of a turn of the milled head suffices for this. A delicate level, which shows a bubble displacement of $\frac{1}{10}$ in. for 40 seconds of arc, is secured to the telescope body and is read without shift of the observer's position by means of the hinged reflector shown. The micrometer levelling screw tilts the telescope through an angle corresponding to a grade of 1 in 100 for each complete turn. The divided head of this screw is shown to a larger scale in Fig. 2. The fiducial line is, it will be seen, curved, this correction being made by actual test of the instrument after completion. The range of elevation provided is ± 5 deg. The horizontal circle is fitted with a Vernier reading to 10 minutes of arc. A clamp and tangent screw are provided, and on ground of a level character the instrument serves all the purposes of a theodolite. When desired, a compass is also fitted. The telescope has a magnifying power of 25, and the tube is of duralumin. The eyepiece is screw focusing. The level weighs 6 lb. complete, and its box 4 lb., the weight of the tripod being 8 lb. The box measures 11½ in. by 7 in. by 5 in.

THE LIMITING POSSIBILITIES IN STEAM PLANTS.*

By PROFESSOR A. L. MELLANBY, D.Sc., and PROFESSOR WILLIAM KERR, Ph.D.

THE selection by your Committee of a paper to be devoted to a consideration of the possibilities of steam plants indicates a belief that such a subject is suitable for debate and, perhaps, specially suitable for debate in the North-East Coast district. It is hoped that this will prove to be the case, as the authors are conscious of many points that will bear discussion, even if only for the purpose of clearing their own minds on the matter.

This subject exercises a certain fascination. The past quarter century has witnessed such a tremendous growth in steam plants that we must at times wonder to what ultimate heights they are ascending. The call for mechanical power in this ultra-mechanical age is dominant and unceasing. Only the steam plant can hope effectually to satisfy it. Its supremacy may be to some extent assailed by the oil-engine plant or by the water-power plant, the former on the claims of higher thermal economy, the latter on the more altruistic grounds of fuel conservation. Where small power totals are required, or for certain special purposes, the former may have some advantages; where large water supplies are readily available, the latter may achieve a distinct success. But historical development has so arranged men and industries that large power supplies are mainly required where Nature has not been too lavish with her free stocks. Even where—as in new countries—industry may be partly arranged to suit Nature's endowments the evidence rather points to the fact that the ultimate demand will far outstrip these supplies. The truth is that the steam plant must constitute the main and abiding element in any general scheme of power development. Other forms may encroach to a greater or less degree on some zones of its territory, but its mandate will continue over all the main avenues of civilization until, at least, the physicist demonstrates his ability to tap those micro-cosmic sources of energy involved in the ultimate atomic structure.

The present importance of the steam plant in the main power fields is likely to be greatly enhanced in the near future. Power schemes are losing the purely technical character they have hitherto held and are assuming the qualities of national and international problems. In other words the engineering and financial questions are partly passing from the quiet board room to the open council chamber. It is indeed interesting to find that, within the past few years, politicians have been displaying a superficial acquaintance with all those problems connoted by the term "power development"; and talk glibly and with persuasive eloquence of tidal power, river schemes and interlinkage of plants. When such a subject has reached such a degree of popularity, we may perhaps expect some developments. While those developments may entail a considerable exploitation of water power, it seems undeniable that the backbone of any national schemes of development must lie in the large steam stations.

It behoves us, therefore, to ponder on the limits open to this main process. These may have been frequently discussed. They will bear re-discussion. As we advance, modification of a point of view is generally necessary, and there will be, no doubt, many controversies regarding limits before any limits are reached. Limit analysis in such a subject has some of the fascination—and some of the pitfalls—of map reading in buried treasure romances. The map is usually a bit vague, but what is not clear to the vision is covered by the imagination, which becomes particularly active in the event of a hiatus in the sequence of facts. In such a technical subject as that on which we are now engaged we must, however, restrain the impulses of high romance and confine our attention to the cold evidence.

The past six years or so have seen a rather remarkable development in steam pressures and temperatures, accompanied by elaboration of the steam path in the forms of reheating steps and extraction feed heating. The promise of these developments has been well understood by steam engineers for quite a long time. Only now, however, are these lines of advance being exploited. The perfection of engineering technique is obviously a potent factor in progress, and it has always to be borne in mind that, as we strive forward, the demands on that quality are intensified. Since, however, the main lines of the recent strong advance in steam plants are not new in conception, the main features of future movements are unlikely to show dramatic changes of form. There may be, of course, spectacular developments in fields akin to it—as, for example, in binary fluid machines—but we are here dealing explicitly with steam plants only. Our problem, therefore, is to discuss the probable limits to well understood processes. We propose to consider each effect separately with the hope of deciding whether an absolute or practical limit really exists. We may commence with the temperature consideration.

The Temperature Limits.—This is strictly and entirely a problem of materials. Thermodynamically there is no limit to the upper temperature that may be used, but the weakness and deterioration of metals under high-temperature conditions must introduce a real limit. Hence, the evidence regarding temperature limits must be sought in the properties of materials. If this evidence is not forthcoming, or is inconclusive, we must postulate the unlikelihood of advance in this direction. Alternatively, we must allow any step that the evidence supports.

All materials weaken in strength with increase of temperature above a certain limit. The rate of weakening may be very considerable. So much so that in the neighbourhood of 1,000 deg. F. many materials cease to offer any reasonable strength or certainty of safety. When we concentrate on the higher temperature ranges, we have almost automatically to reject most of the non-ferrous metals from the list of available materials; and we are left with steels and a few special alloys.

The usual curve on a base of temperature shows the

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders at Newcastle-upon-Tyne on February 27.

stress carried by the specimen when loaded up to breaking point after having been heated to the temperature required. Fig. 1 shows a few typical curves of the kind, and is introduced to facilitate reference. It will be seen that, according to this figure, there are three main fields for any metal; (*a*) that of steady and full strength; (*b*) that of falling strength, and (*c*) that of weakness. The first is the field of actual use; the third is that of absolute uselessness; and the second is at once the field of progress and of danger. How far can we advance into this field? To answer that we must study the danger signals and determine their trustworthiness before marching forward according to their indications. The modern steam plant utilises 750 deg. F., and there seems little sign at the moment of any strong desire to increase it. Yet Fig. 1 tells us that around 1,100 deg. F. monel metal and steels still retain a strength of roughly 20 tons. There would seem to be ample margin for advance here!

Unfortunately, these very common types of curves only tell us very simple facts; their general use in engineering literature and advertisement is somewhat to be deprecated, since they obscure real issues and throw favourable but partial values into a false prominence. In actual working the question is not one of how violent may be the death of a material, but rather of its length of life under the conditions of living open to it. Fig. 1 charts violent deaths. What, on the other hand, is the intensity of action that, under stated conditions, will lead to longevity? Such is the real question. In practice the material has to carry its load continuously. Further, the load may fluctuate regularly. In fact, the general loading conditions comprise a cyclic variation of stress superposed on a steady mean value at or around a definite high temperature. The conditions under which the curves of Fig. 1 are obtained are in no wise representative of these facts. We are, indeed, brought up against the modern material problems of fatigue and time effects. We must ask how these influence the danger signals; have the warnings of Fig. 1 to be made more or less vehement to cover for the influences therein ignored?

Fatigue limits have been well explored at normal temperatures and the relationship between safe ranges of stress and mean stress are reasonably well known. But the same can hardly be said of high-temperature conditions. The work in this field has been only partially completed so far. At normal temperature the "Gerber" parabolic law applies, viz.:—

$$S_f = S_o \left\{1 - \left(\frac{M}{U}\right)^2\right\}$$

when S_f is the safe range to be superposed on the mean stress M; S_o is the safe range with M zero; and U is the ultimate strength. With temperature increase we have seen in Fig. 1 that the ultimate strength falls rapidly. Does this entail a correspondingly large reduction in the fluctuating range? We should naturally expect so.

Peculiarly enough, work by Lea and Budgen* shows that such is not the case. The curves in Fig. 2 are reproduced from their figures and show maximum stresses for different mean stresses and increasing temperatures and for more than 10×10^6 repetitions. It will be seen that there is but little fall off in the stress range at even 1,200 deg. F., when undoubtedly the direct breaking strength is seriously reduced. Lea also cites the case of a steel which had an ultimate strength of a few tons only at 1,300 deg. F. which yet carried 17·5 tons at about that temperature for many million reversals without fracture.

Such extraordinary results are rather incomprehensible. We are here, fortunately not concerned with the reasons but only with the facts. It may ultimately transpire that the rate of reversal has an important influence on the range of stress at the high temperatures; but the evidence so far obtained certainly leaves the conviction that the breaking strength as determined by the usual direct test is a more serious and more emphatic disclosure of the inherent weakening due to temperature than can be derived from fatigue tests. It would appear that, if working stresses at high temperatures were safely related to the ultimate, the fatigue action could be ignored—in fact it would seem to put the material into more favourable condition.

It may, however, be remarked that we are not necessarily endorsing this as a generally advantageous influence of fluctuating stress at high temperatures. Further testing at various rates may show up otherwise, but the essential fact for our purpose would appear clear. With increased temperature the material is not so seriously weakened against fluctuating stress as against direct stress. Consequently the ultimate strength curves of the type in Fig. 1 are the safer and more definite criteria of the temperature influences.

The actual part has, however, to carry its load in the high temperature atmosphere for long periods. This brings us to the most momentous results of recent materials testing, viz., the time influence. That time under load has a definite influence is probably quite well appreciated in metallurgical circles, but it seems less well understood by engineers. At high temperatures a very moderate stress—well under the breaking values recorded by the Fig. 1 type—will produce ultimate failure of the specimen by creating and maintaining continuous elongation. Dickenson calls this "flow"; Lea has called it "creep"; and both of these investigators provide sufficient evidence to show that the ultimate stress curves of Fig. 1 are useless as bases of judgment for the effect of temperature on strength.

Dickenson's* results are highly instructive. He has

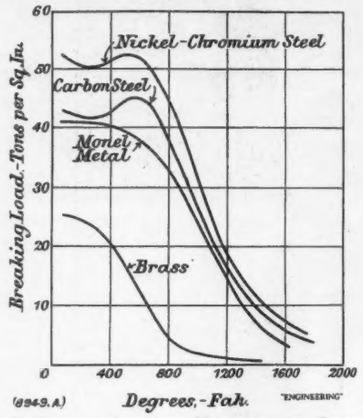


FIG. 1. TYPICAL STRENGTH-TEMPERATURE CURVES.

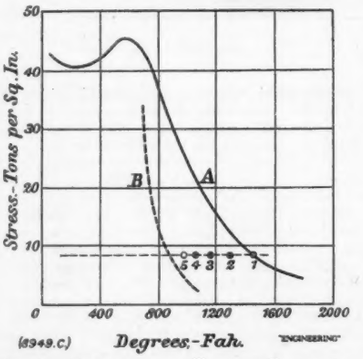


FIG. 3. INFLUENCE OF TIME ON STRENGTH.

Curve A.	Breaking strength ...	0·3 C. steel.	Dickenson.
Point 1.	Creep test, 6 secs. break	,,	,,
Point 2.	Creep test, 3 min. break	,,	,,
Point 3.	Creep test, 28 hours break	,,	,,
Point 4.	Creep test, 956 hours break	,,	,,
Point 5.	Creep test, 3,400 hours unbroken	,,	,,
Curve B.	Creep limit curve from values for	0·32 C. steel.	Lea.

taken a series of different steels and determined their length of life under a stress of 8·5 tons at different temperatures. In all cases this gives a curve showing the temperature reducing asymptotically towards a limit—in fact, the curve type is similar to fatigue range curves with temperature in place of stress and time replacing number of reversals. Taking one case for illustration, the full line in Fig. 3 shows the ordinary strength-temperature curve for one steel, while the row of marked points indicates the temperatures at which a stress of 8·5 tons caused fracture in the stated times. The evidence hereby provided is that, for this steel, a stress of 8·5 tons would give a quick failure at 1,420° F., but would still cause failure at between 900° F. and 1,000° F. if sufficient time were allowed.

Lea† carries the matter a little further. He distinguishes between stresses that cause "continuous creep" and those which produce a "non-continuous creep." We may for convenience call the point of change the "creep limit." This creep limit for Dickenson's steel above quoted is then 8·5 tons at about 1,000° F. Lea, however, provides more general information from which we can derive a useful view of the matter. He specifies the stresses at a few temperatures above which creep is continuous, *i.e.*, he gives a few "creep limits." Taking his values for a steel somewhat similar to that of Dickenson's the dotted curve of Fig. 3 is obtained.

The relation of the full and dotted curves, *i.e.*, of the quick and slow ultimate fracturing stresses on temperature is very surprising. The curve of ultimate strength—using the word ultimate in its most general sense—is sheared back over an extraordinary range. The dotted curve of Fig. 3 may, of course, be too far back in this particular case, since the data came from

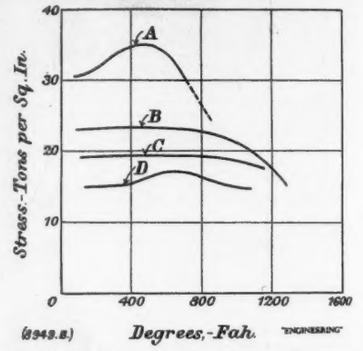


FIG. 2. SAFE RANGES AT 10 MILLION REVERSALS.

Curve A.	Breaking strength ...	0·14 C. steel.	Lea and Budgen.
Curve B.	Max. tension with mean of 15 tons/in². ...	,,	,,
Curve C.	Max. tension with mean of 10 tons/in². ...	,,	,,
Curve D.	Max. tension with mean of 0 tons/in². ...	,,	,,

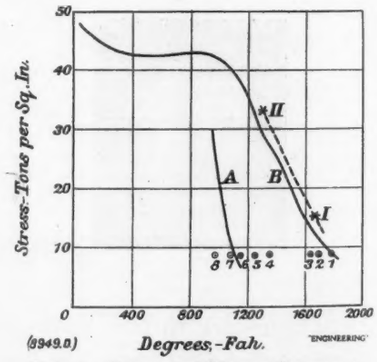


FIG. 4. VALUES FOR NICKEL CHROMIUM ALLOY STEEL.

Curve B. Breaking strength. Ni-Cr. Alloy. Dickenson.
Points I & II. Breaking strength. Special steel. Hadfield.
Point 1. Creep test. Ni-Cr. Alloy. Dickenson. 6 secs.
Point 2. Creep test. Ni-Cr. Alloy. Dickenson. 1 min.
Point 3. Creep test. Ni-Cr. Alloy. Dickenson. 3 min.
Point 4. Creep test. Ni-Cr. Alloy. Dickenson. 273 hrs.
Point 5. Creep test. Ni-Cr. Alloy. Dickenson. 901 hrs.
Point 6. Creep test. Ni-Cr. Alloy. Dickenson. 6,041 hrs.
Point 7. Creep test. Ni-Cr. Alloy. Dickenson. 3,604 hrs. (withdrawn).
Point 8. Creep test. Ni-Cr. Alloy. Dickenson. 521 hrs. (withdrawn).
Curve A. Assumed creep limit.

different sources, but the agreement with the chain of points at 8·5 tons/in.² is sufficiently good for our purposes here. The general fact applies to all steels investigated by Dickenson or by Lea and, presumably, will be found also applicable to non-ferrous materials. Due to creep the rapidly falling strength-temperature curves of Fig. 1 change to the almost precipitous type shown by the dotted curve of Fig. 3. Because of this rapid drop greater uncertainty must exist as to the truly safe values within the falling range; and the whole field between the dotted and full line curves of Fig. 3 must be avoided as treacherous ground.

It will be seen that this dangerous area narrows towards the high stress values. It looks as though it would taper away at or about the point where the normal strength begins to fall off rapidly. This point

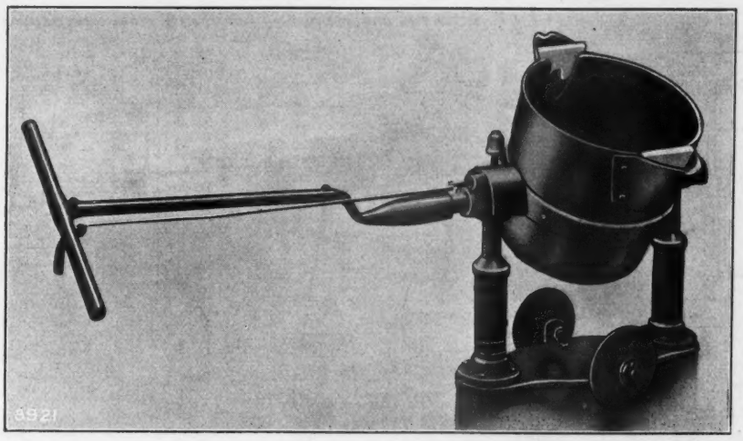
* "The Effect of High Temperature on the Range of Repetition Stresses on Steel," Lea and Budgen, British Association, August, 1924. ENGINEERING, October 3, 1924.

* "The Flow of Steels at a Red Heat," Dickenson, *Proc.* Iron and Steel Institute, September 6, 1922. ENGINEERING, September 15, 1922.

† "The Effect of Low and High Temperatures on Materials," Lea *Proc.* Institute of Mechanical Engineers, December 5, 1924.

SELF-LEVELLING FOUNDRY LADLE.

THE CONSTRUCTIONAL ENGINEERING COMPANY, LIMITED, BIRMINGHAM.



of inflexion on the ordinary curve is then a "cut-off" point of some importance. It not only denotes the value at which the influence of temperature definitely begins to make itself felt, but it also marks the point at which the time factor enters freely into the question. It would seem to be a suitable place at which to erect the main danger signal!

The fatigue limits obtained by Lea and Budgen have appeared surprising enough in relation to breaking strengths, but how much more so are they now in relation to creep limits! It must be admitted that some anomalies appear in this matter. It would, for instance, seem possible to have a mean stress just above the "creep limit" together with a considerable fluctuating stress, which would be safer than the mean stress alone over long periods. The incidence of time on the problem can hardly be so simple as it appears at first sight.

Such special issues apart, however, it would seem certain that the field of falling strength due to temperature is essentially dangerous for engineering constructions involving high stress at high temperatures. This general conclusion is quite uninfluenced, but is staunchly supported, by the other disadvantages of the high-temperature field such as the uncertainty or absence of a limit of proportionality, the proneness to growth or ease of distortion, and the possibilities of oxidation with its attendant troubles. These detail faults of the field, together with the definite weakness disclosed by creep-limit considerations, demonstrate that, for the ordinary steels and the best non-ferrous materials as we know them, an upper limit of 750° F. to 800° F. seems a maximum. The existing upper temperature limit for steam plants appears rational.

If, however, materials can be obtained or can be developed which give strength-temperature curves lying conspicuously to the right of those in Fig. 1, say, it would become possible to increase temperatures accordingly, always provided that the other deleterious influences due to high temperatures do not more than counterbalance the added strength. This introduces the question of improvements in steels. Non-ferrous materials may be practically ruled out. What are the present indications of advance? So far as the authors are aware the best results claimed are those voiced by Sir Robert Hadfield at the World Power Conference* last July. The information he gave was brief and to the effect that a new steel had been developed which was non-scaling up to 1,900 deg. F., and resisted the sulphurous products of combustion. It had a strength of 33 tons at 1,300 deg. F., and of 15 tons at 1,650 deg. F. Enough information to surprise but not to satisfy! But we find in Dickenson's comprehensive tests a nickel-chromium alloy which has approximately these strengths, and we may therefore get some idea of the real limits by considering his results for this material. We have to realise that the suitability of any metal for use at high temperatures will have to be judged from such values as the "creep limits" we have been discussing. The direct strength at a given temperature may show the likelihood of superior values, but is not a proof thereof.

Fig. 4 shows Dickenson's results for his nickel-chromium alloy, while the two points outside the curve represent Sir Robert Hadfield's quoted values at 1,300 deg. F. and 1,650 deg. F. The chain of points at the 8·5 tons stress conveys the information to be obtained from Dickensons' creep tests. We may be permitted to use this information to sketch in a probable "creep limit" line as indicated by curve A. It would then appear that this steel ceases to be useful for high-stress high-temperature applications at around 900 deg. F. to 1,000 deg. F. It is probable that Sir Robert Hadfield's steel has a similar limit. These materials seem to be used in the construction of containers for synthetic ammonia plants, and higher temperatures may be permitted therein. But occasional replacement may be feasible in such cases, whereas in the high-temperature parts of steam plants such is not possible, and the working temperature will be more conservative.

Curve B of Fig. 4 seems typical of the form necessary in the development of steels for high-temperature uses. The initial strength is not excessive, but the flat "table-land" showing its retention over a wide temperature range is very pronounced. It is in extending this flat top and in narrowing the useless field between the breaking strength and creep-limit curves that the ideal will probably be found; and that ideal may have as a noticeable feature a comparatively low initial strength.

On the whole evidence the authors venture the opinion that 900 deg. F. represents the steam-plant limit. They consider this figure a generous estimate that allows the possibility of fair advance to the metallurgist, discounts some of the main difficulties of that advance, and admits the necessary conservatism of the steam engineer. The assumption is open to question, of course, but it seems probable that the range of criticism could only be about 50 deg. F.

(To be continued.)

* See ENGINEERING, July 11, 1924.

SELF-LEVELLING FOUNDRY LADLE.

ONE of the minor problems of the iron foundry connected with the efficient handling of any large contract for repetition castings has been the difficulty, when using ordinary bogie ladles, of obtaining a constant pouring level. When pouring a series of moulds with a full ladle, the pouring point is apt to be too high, while when it is three-quarters empty the tilt which has to be given to the ladle may make it too low to clear the mould, thus necessitating frequent runs back to the cupola for the purpose of keeping the ladle constantly charged between these limits. A contract for repetition work at a cut price, such, for instance, as chairs for railway permanent way at 10*l.* per ton, can only be handled without unfortunate financial results when labour charges are reduced to a minimum. The difficulty is a very similar one to what was experienced during the war in producing the enormous quantities of bar brass required, and which in the case of the brass foundry was met by various designs of tilting furnace, arranged (by means of a more or less complicated system of gearing, chains, and balance weights) to provide a fixed pouring point beneath which the moulds were brought successively.

The requirements of ironfounders who utilise ladles between 6 cwt. and 12 cwt. capacity are met by a new design of self-balancing bogie ladle, which has been introduced by the Constructional Engineering Company, Limited, of Titan Works, Charles Henry-street, Birmingham. The ladle, which is illustrated in the annexed figure, provides for a constant height of pour. The main feature of the design lies in the carrying of the trunnions on vertical pillars each resting on a coiled spring. The springs are compressed to their full extent by the weight of a full charge of metal and extend gradually as the metal is poured, so that the ladle is maintained at a constant pouring level. As can be seen from the figure, the ladle is provided with renewable lips and refractory skimmers, which prevent any slag on the surface of the metal being poured into the mould. The ladle can be handled by one man and the same handle is used for trailing and tilting. A safety catch, operated from the handle, is provided to guard against any accidental tilt. Easy running along the trolley-ways of the foundry is assured by special disc wheels, with conical rims which are carried on ball bearings.

SYNTHETIC LIQUID FUEL.

THE manufacture of synthetic petroleum on a commercial scale, has been much to the fore in France since the war. The object aimed at by the scientists and engineers who advocate its use is to render the country absolutely independent of outside supplies of liquid fuel and also to utilise to the fullest extent the natural resources, both actual and potential, of France and her colonies. Synthetic petroleums, as is well known, have been obtained in laboratory researches for many years past, starting from animal and vegetable fats, and from coal, shale, lignite, peat, and vegetable matter or refuse of various kinds. With a view to encourage developments, the Ministry of Agriculture instituted in June of last year a congress and exhibition to demonstrate the value of such synthetic products and the possibility of obtaining them in quantities adequate to meet the country's needs. The exhibition and congress took place from September 30 to October 5, under the auspices of the French Central Committee for Mechanical Cultivation, a body established in May, 1921, by the same Ministry, for the encouragement of the use of machinery and mechanical appliances in ploughing, reaping and farm work generally.

In the course of the meetings of the Congress reference was made to the pioneer work of the late M. Marcelin Berthelot, who about 75 years ago succeeded in transforming into hydrocarbons over one hundred different organic substances.

One of the papers, by M. Mailhe, Professor at Toulouse University, was of special interest. It dealt with the extraction of synthetic petroleums from vegetable and animal oils, and, after giving historical data, M. Mailhe explained how he obtained the synthetic products he aimed at by the catalytic decomposition of linseed oil. By treating under similar conditions rape-seed, olive, ground-nuts, palm, copra, fish, whale and other oils, a very similar petroleum was obtained. Castor oil, besides hydro-carbons, yielded a certain quantity of œnanthole, an aldehyde utilisable directly or after transformation by hydrogenation. Slight differences noticed in the various synthetic petroleums obtained did not arise from the different nature of the oils treated, but more from variation in the temperatures of reaction, or from the greater or less activity of the catalytic agent, or, again, from the rapidity with which catalysis was effected. The method followed had been applied both to the raw oils and to those refined. The actual cost of manufacture of synthetic petroleums being low, the cost of the products themselves depended mainly upon that of the oils to be treated. A prime necessity, therefore, was to provide for the rational cultivation on a large scale of the suitable seeds and nuts, in order to decrease the cost of vegetable oils much below the market prices now ruling. The same paper alluded to the treatment of chlorophylle extracts for making synthetic petroleums; these extracts could be obtained comparatively cheaply from numberless plants, without detriment to the other customary uses to which many of them were now put.

Another contribution of interest was that by M. E. Goutal, Professor at the National School of Mines, describing the Andry-Bourgeois and Olivier process. In this, the author stated, the materials used were of the cheapest, namely, water and carbon, the latter being any carbonised organic substance. The carbon was first combined with oxygen, yielding carbon monoxide. In a second phase the CO reduced by hydrogen was transformed into methane, $CO + 3H_2 = CH_4 + H_2O$. In a third phase methane was electrically dissociated, yielding acetylene $2CH_4 = C_2H_2 + 3H_2$. Finally, the acetylene was polymerised and hydrogenated catalytically, yielding in the last resort petroliferous hydrocarbons, both liquid and gaseous.

Other papers dealt with motor alcohol, and with the various advantages attendant upon the cultivation of beetroot; with low-temperature carbonisation

22/26-H.P. FOUR-CYLINDER PARAFFIN ENGINE WITH REVERSE GEAR.

CONSTRUCTED BY THE ORION ENGINEERING COMPANY, LIMITED, ENGINEERS, LEEDS.

Fig. 1. PARTIAL SECTIONAL ELEVATION.

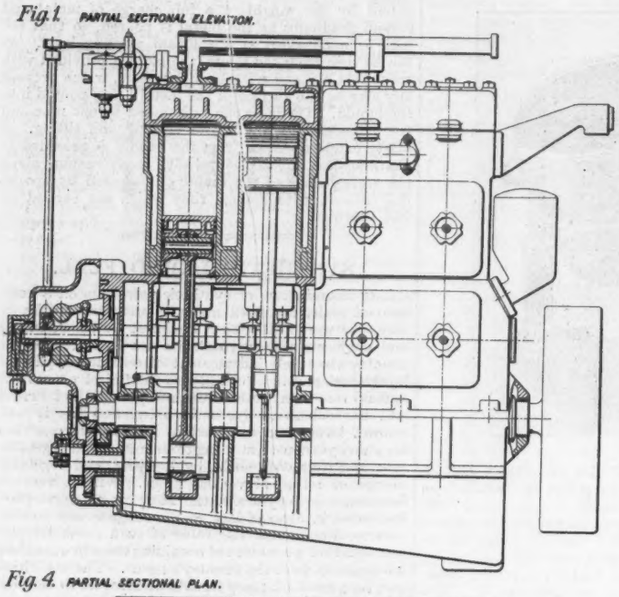


Fig. 2. SECTION THRO' CYLINDER & VALVE.

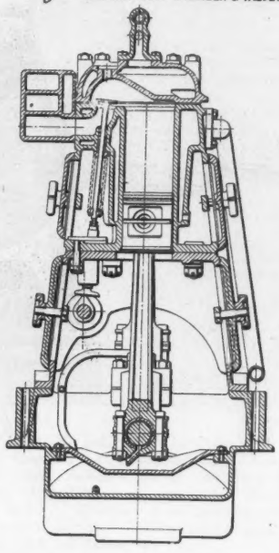


Fig. 3. FORWARD END ELEVATION

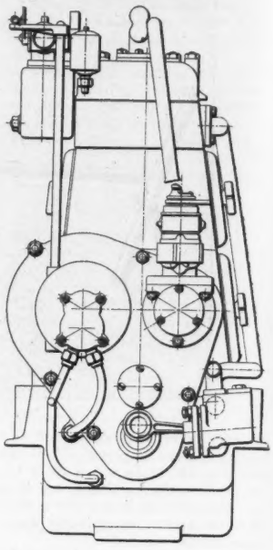


Fig. 4. PARTIAL SECTIONAL PLAN.

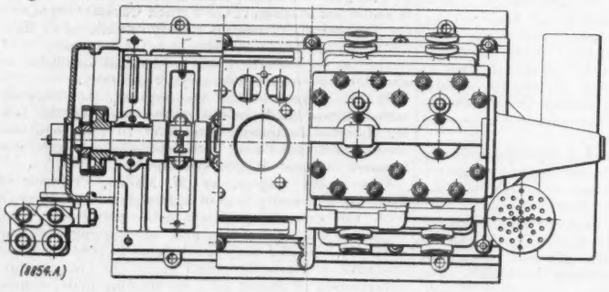


Fig. 5. GEAR WHEELS.

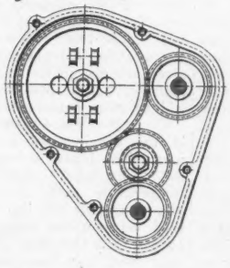


Fig. 6. SECTION THRO' MAGNETO DRIVE.

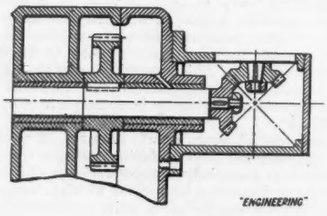


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Fig. 7. LONGITUDINAL SECTION.

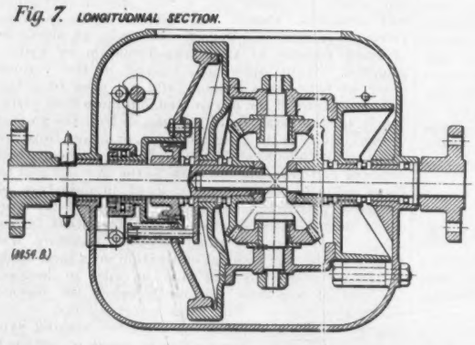


Fig. 8. CROSS SECTION SHOWING CLUTCH.

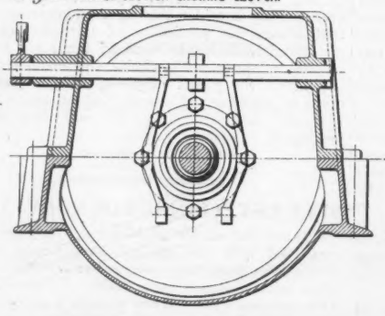
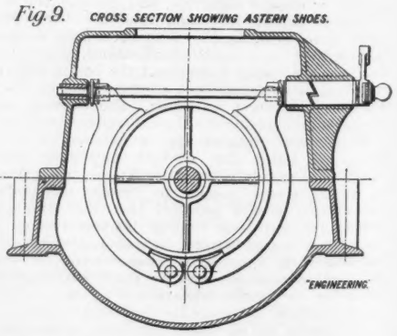


Fig. 9. CROSS SECTION SHOWING ASTERN SHOES.



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as applicable to the subject under consideration, and with other processes, including the Bergius process which is followed in Germany and is referred to on page 193 *ante*. The paper concerning this mentioned several Bergius patents for obtaining light hydrocarbons, starting from heavy ones, the substance dealt with in another patent being coal. There was no doubt in the minds of the members of congress that Germany was dealing actively with the liquid fuel question, and was intently pushing forward the manufacture of synthetic petroleums.

Special interest also attaches to a paper by Mr. Lumet, of the French Automobile Club, describing the direct use as a fuel of vegetable oils in internal-combustion engines. It gave an account of a series of tests made by the Club of several engines which ran on ground-nut oil, shale and colza oils.

The complete report of the proceedings of the congress and particulars of the exhibits have been published by *Chaleur et Industrie* as a supplement to their last December issue.

22/26-H.P. ORION PARAFFIN ENGINE.

ONE of the main characteristics of the paraffin engine illustrated above and on page 305, is the way in which the accessibility of the working parts has been kept in view throughout the design. The engine is a product of the Orion Engineering Company Limited, of Standard Buildings, Leeds, and was constructed in the works of the firm at Aldbourne-road, Coventry. It is capable of developing 22 to 26 brake horse-power and has four cylinders of 3¼-in. bore and 6-in. stroke. This is the smallest of three standard four-cylinder, four-stroke engines, the others being of 42/46 and 62/66 brake horse-power. These have the same constructional features as the small set, and in them the same high ratio of stroke to bore, 1·55, is used. It may be thought that this ratio is too high, but as it allows the use of smaller width than is commonly the case for the upper part of the engine, it has the advantage of causing little obstruction when the engines are installed as power units in motor boats. This construction has also the advantage of facilitating dismantling for repairs or overhauls in a confined space.

The general features of the design will be followed in the elevations, sections, and plans shown in Figs. 1 to 4, while the general views of the two sides and the end, given in Figs. 10 to 12 on page 305, clearly show the completeness with which the moving parts have been enclosed and the compact arrangement of the whole set. The crank-case is cast in two parts, the lower one of which carries the crankshaft and main bearings, while the upper one gives support to the cylinders, which are cast in pairs. As will be clear from Figs. 2 and 3, the upper part of the engine takes the form of a truncated wedge. The junction of the detachable heads and the cylinders is level with the top of the bore.

In shape, the combustion chamber is deep over the valves and diminishes in cross-section to about two-thirds of the width of the cylinder, the remainder being horizontal. This form was adopted to obtain

22/26-H.P. FOUR-CYLINDER PARAFFIN ENGINE WITH REVERSE GEAR.

CONSTRUCTED BY THE ORION ENGINEERING COMPANY, LIMITED, ENGINEERS, LEEDS.

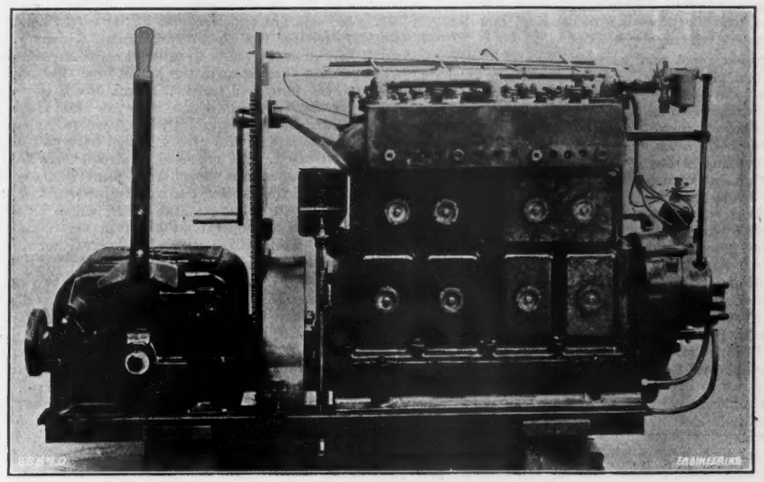


FIG. 10. STARBOARD SIDE OF ENGINE.

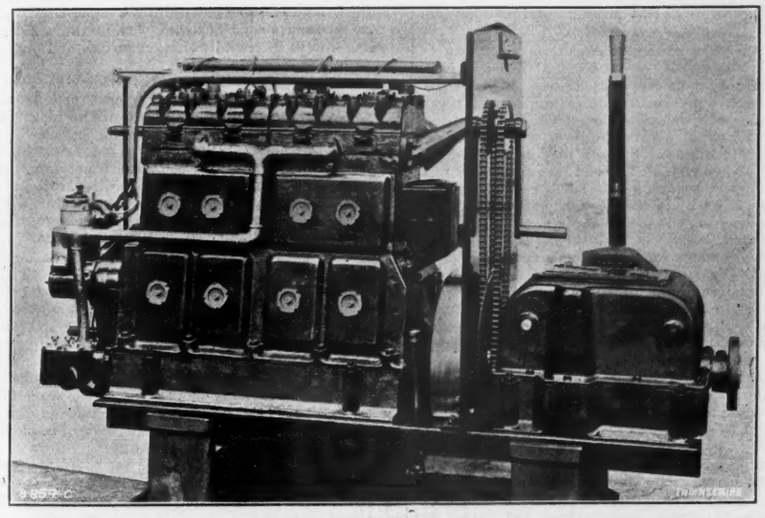


FIG. 11. PORT SIDE OF ENGINE.

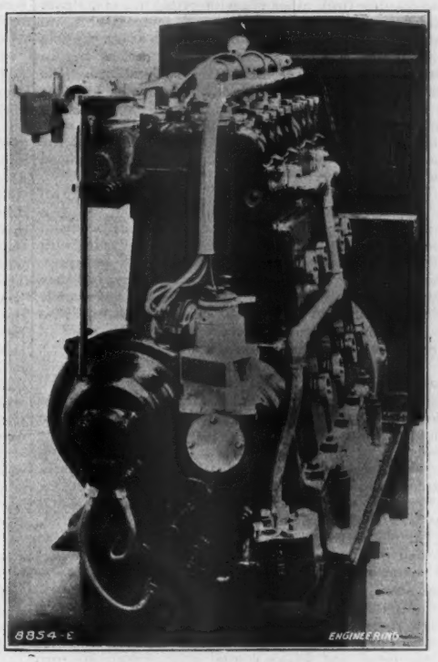


FIG. 12. END VIEW.

the maximum possible turbulence for the gases. A small refinement introduced into the design of the cylinder castings and the detachable head, is the provision of lugs, between which pinch bars can be inserted to enable the joint to be eased, prior to the removal of the cylinder heads, without damaging the faces. It will be observed from the sections in Figs. 1 and 2 that the water-jackets are free from any recesses which might affect the clear passage of the water. The water pump is driven off the crankshaft through the medium of a pair of gear wheels. It is of the plunger type, and as its driving wheels are entirely independent of the main timing wheels of the engine, it may be quickly removed as a unit for inspection whenever necessary. The water-pipes from the pump to the cylinders are arranged to permit an even distribution to be obtained for each. In addition, they are carried up the engine in a manner which avoids all obstruction to the removal of the crank-case doors or valve-spring covers.

A scraper ring and two main piston rings are provided on each of the cast-iron pistons, while a further ring is used to retain the hollow gudgeon pin in position. Scoring of cylinders is always a source of trouble and to assist in preventing it starting in the cylinders of this engine, both top and bottom of the cylinders are chamfered. The connecting rods are fitted with phosphor bronze bearings for the gudgeon pins, while the crankshaft is mounted in five bearings of gun-metal with white metal linings. Adjustable shims are provided for the big-ends of the connecting rods and also for the main bearings. The camshaft is supported in three bearings and the cams are both keyed and pinned on it. With the timing wheels, the bearings and the governor, the camshaft may be dismantled as a complete unit, when the timing case is removed from its place. The centrifugal governor is mounted on an extension of the camshaft, and outside the timing case the same shaft is used to drive the lubricating oil pump. The valves are inclined to the cylinder barrel, as is seen in Fig. 2, and are operated from the camshaft through the medium of tappets with large circular bases. As these are set off from the centre lines of the cams, they continually rotate, and this action is useful in assisting the lubrication of the valve-operating gear. The vaporiser is of the Bradburn-Cox type. The paraffin is first sprayed through a Cox "Atmos" carburettor, and impinges against a hot part of the pipe system, against the other side of which the exhaust gases play. The governor is arranged to cut out when the engine speed is 750 r.p.m., and acts directly on the throttle, which is also separately controlled by means of a simple fine adjustment from a lever on the dashboard or other suitable position.

An oscillating oil pump driven from the forward end of the crankshaft, draws the oil from a sump in the crank-case and delivers it to each of the main bearings and to the troughs below the big ends of the connecting rods. Here there are dippers which carry oil to the big-end bearings. All other parts of the engine are effectively lubricated by the splash method. A depth rod is fitted at the after-end of the crank-case on the port side, while a hand oil pump on the other side enables the crank-case to be easily emptied for oil replenishment purposes. A large filler is accommodated beside the starting bracket at the after end of the crank-case, see Figs. 1 and 4, and it also acts as a crank-case breather.

For ignition a vertical spindle magneto is mounted outside the timing-case and is driven from the main timing wheels. The drive is taken from the top right-hand wheel in Fig. 5. A section through the equipment at this point is given in Fig. 6 which shows the bevel arrangement used to obtain the vertical magneto drive. Inspection of the make and break and of the distributor may be made without any difficulty, as will be clear from Fig. 12. The reverse gear, the details of which are illustrated in Figs. 7, 8 and 9, is of the bevel epicyclic type, the clutch of which is operated by means of a rotating cam controlled externally from the main lever by means of an outside fork. A similar control system from the main lever is used for the brake shoes for the astern drive. The motion to put the reversing brake on and take it off is obtained by means of a shaft, cut with inclined faces and steps, engaging with corresponding teeth on the tie rod of the brake shoes (see Fig. 9).

The starting gear is clearly indicated in Figs. 10 and 11 and consists of a pair of sprockets, the upper one of which can be set eccentric to the shaft, on which it is rotated, to varying amounts, in order that chain adjustments may be made. The lower sprocket is fixed to the forward shaft of the reverse gear, which is located beside the flywheel. In Fig. 11, it may be observed there is every appearance of the use of two chains for the starting gear, but this is an illusion due to the reflection of the chain on the highly-polished board beside it.

THE BRITISH CORPORATION REGISTER BOOK.—The Register Book of the British Corporation for the Survey and Registry of Shipping, which has just been issued for the current year, contains tabulated data of all the vessels classed in that Registry, as well as lists of the general and Liverpool committees, the surveyors in British and foreign ports, and other information relating to the Corporation and its work. The book is issued to subscribers only, the subscription being three guineas for individuals and firms, and four guineas for underwriting associations and marine-insurance companies. The address of the head office of the British Corporation is 14, Blythswood-square, Glasgow.

STEAM PIPES FOR EXTRA HIGH PRESSURE AND TEMPERATURE.*

By J. Arthur Aiton, C.B.E.

During the last few years, and under the stress of competition from other types of prime movers, steam pressures have steadily risen and temperatures are commonly in use which are about as high as are possible with present materials. Any further serious rise in temperatures will necessitate reconsideration of the material of which steam pipes can be made, but this is not yet a live question. Increase of pressure does not necessitate any radical change in the pipes, as it can be met by increased thickness of wall, and the tendency with increased pressure is towards reduced diameter of pipes.

This paper will deal chiefly with deductions drawn from actual experience of pipes working under a maximum temperature of 750 deg. F., with a steam pressure of 400 lb. per square inch, and not with abnormal conditions. Such temperatures and pressures have not produced any new difficulties, but they have accentuated all the old ones, and have made it more than evident that the design of steam piping is as much a matter for expert knowledge as that of any other item in the power station.

The design of the pipework should not be made entirely subservient to the exigencies of power-station design; it is not expected that a station should be designed round the pipework, but piping is so often the last thing to be considered in the layout that the designer, in having to avoid obstacles which should never have been placed in his way, such as pumps, fan casings, and tanks, to mention only a few examples, is forced to depart from the run which he knows would be best for the pipes to take.

Simplicity should be the first consideration in the design of pipework, and piping should take as direct a course as is compatible with due provision for expansion. Pipes are now so reliable, and the chance of an entire breakdown is so small, that it is quite unnecessary to duplicate them. Duplication is very expensive; it largely increases the probability of radiation losses, and by its complication defeats its own ends by increasing the risk of breakdown. The diameter of the pipes should be kept small by a high-velocity flow which is obtainable by a drop in pressure, say as much as 10 lb. This may sound high, but is not serious when compared with the initial pressure, and any loss which arises from this drop is fully compensated for by reduced radiation loss and by a reduction in capital charge. It may be remembered that full drop is only incurred at maximum output, and falls very quickly at lower loads.

Having settled the size of the pipes and generally how they are to run, the next problem to be tackled is that of expansion. With high superheat this is indeed a serious question, and is the ultimate cause of most of the trouble in pipe lines. Even troubles with joints may often be traced back to undue stress on the flanges by expansion of the pipes.

It is convenient to consider expansion under two classes. Firstly, the natural, which is due to the variations from dead cold to the highest steam temperatures and cannot be avoided, as it is inherent in the use of high superheat. Secondly, that due to extraneous causes, which may be to some extent inherent, but can be largely, if not entirely, eliminated. It is important that this distinction should be remembered, for in the first case the design will have to provide sufficient flexibility to take up the movement due to expansion, whereas in the other the design will aim at removing the cause, and so the movement. The first case can be easily met by providing wide bends in the run of the pipes. This is the most desirable arrangement, but where it is not possible the next best thing is to introduce expansion bends of the lyre type. It is advisable to allow for the pipes to be drawn up when cold to the amount of about one-third of the expansion arranged for. It may be accepted that sliding expansion-pieces, however alluring they may look on paper, are not suitable for the conditions being dealt with here.

In order to be effective, expansion bends must be large, and, consequently, they take up considerable space, which is often difficult to secure. To surmount this difficulty, bends made from corrugated pipes are now being used, as they have much greater flexibility than those made from plain pipes. It is, therefore, possible to make them of much smaller dimensions and still obtain the same amount of movement for expansion; or conversely, if made to the same dimensions, five times the amount of movement for expansion can be obtained, and, moreover, much smaller thrust is required in order to spring them. Corrugated pipes are stronger than plain pipes because the process of manufacture thickens the crown and the base of the corrugations, and they can only be made from the best quality of tube. They can be bent very easily, and the smaller sizes cold, but as this punishes the metal it is not recommended as a regular practice, although it may be a very useful feature in fitting bends into position. Experience shows that it is better to heat the pipes before bending, but it is not necessary to pack them with sand.

Corrugated pipes can be bent to a much smaller radius than plain pipes, even small enough to enable them to take the place of a cast elbow. There is very little expansion movement with such a short bend, but it enables wrought steel to take the place of a casting, and will often eliminate a pair of flanges. As regards bending, wrought-steel tubes compete favourably with those of copper, and are twice as flexible. As final bends to turbines their added flexibility in all directions, is a great advantage, for they not only give more movement along the axis of the bend, but they also give considerable movement transversely without engendering a heavy thrust on the turbines. The friction loss in steam passing round corrugated bends is double that in bends made of plain pipe of the same radius, but as the number of bends used can be reduced, in favourable circumstances, to one-fifth there is a large margin of gain in this respect. If it is impossible to reduce the number of bends, the difficulty can be overcome by fitting a large bore pipe, which would not necessitate a bend of larger radius, nor would it curtail the movement available for expansion.

A method of making a bend from plain pipe to a radius much smaller than that to which plain tube can be bent is by cutting pieces out of the pipe, bending it with the cuts on the inside of the bend until the sides of each cut meet, and then welding up the cuts. This is a method which should not be used with steam pipes for any great pressure, and certainly not with the pipes under consideration.

There are other classes of expansion which can be at least minimised by care in design. Water in pipes is the cause of the most serious stresses. It is not possible entirely to prevent it from getting into the pipes, but the amount which passes along with the steam does not do much harm. Water, however, which is allowed to collect and lodge in the pipes may do considerable damage. When steam is turned into horizontal pipe in which water has been allowed to collect, unequal expansion is set up in the pipes, hogging takes place, and stresses arise, the ultimate effect of which cannot be calculated.

All pockets where water may lodge must be avoided at all cost. Valves are a great source of water pockets, and if no valves were required in a pipe line, it would be possible to keep water from lodging in the pipes by making all ranges drain into suitable headers, but although this is not possible, it should be kept in mind, and the number of valves reduced to a bare minimum. Simplicity of pipe design is a great desideratum, for redundant valves are a frequent cause of water trouble. Again, valves are often placed in positions where they are bound to form water pockets, as at the bottom of drop legs, but this cannot be wholly prevented, and when valves have to be placed in such a position they should be by-passed for drainage. Valves, of course, are not the only cause of water pockets. Bends rise off valves, causing a pocket above the valve, and expansion bends are set in a vertical position in mains, possibly causing two pockets. These are very obvious cases, but experience shows that constant watchfulness is necessary to prevent such errors creeping into otherwise well-designed pipe lines and causing trouble in working.

Injudicious anchoring causes expansion stresses by endeavouring to force the pipe into a position where it would not naturally go. The ideal plan would be to have no anchoring at all, as under such circumstances it would only be necessary to guide the pipe in the direction in which expansion should take place, but this ideal can seldom if ever be obtained, although it should be aimed at in all cases.

The working of modern steam-pipe lines is a new problem, and must be treated in a new way, for that which can be done with comparative impunity on lower-temperature work will cause very serious trouble if attempted with high-temperature work. For instance, to bring a boiler on to a main carrying superheated steam ought to be a very slow process if trouble with pipes is to be avoided.

Referring to questions of the design and manufacture of the pipes themselves, undoubtedly, the weakest part of the pipe line is the joint, and as every joint is a potential cause of trouble, the obvious aim should be to reduce the number of joints to a bare minimum by making each pipe as long as possible. As castings, even of steel, are no longer used in first-class pipework, and as modern methods allow branches to be fixed to any part of the pipe, it is possible to use straight pipes up to 25 ft. or even more, and 30 ft. is quite a common length. Obviously, it is not always possible to take advantage of the longest lengths of tube, especially with bends, owing to the lack of facilities for transport.

Elimination of joints by welding up pipes in long lengths on the site is very attractive, but there has not yet been sufficient experience to justify recommending its adoption for the highest pressures. At any rate, great care must be taken to prevent cross stresses due to expansion coming upon the joints, or if this cannot be done the joint will have to be reinforced to resist such stresses. A joint which aims at this result is that known as the "Sargol" joint, used in America, in which the end of the pipe is rolled over and loose flanges are used. All mechanical stresses are taken by the flanges, and a steam-tight joint is made by welding round the edge of the rolled-up portion of the pipe. This system has its drawbacks, which have so far prevented its general adoption in this country, where fixed flanges are almost universal for high-pressure work.

In the use of flanges for piping there are two main questions to consider, namely, how to attach the flange to the pipe, and how to make the joint between the flanges. Regarding the first, there are nowadays only two methods of fastening flanges to pipes, namely, by riveting and by welding, except in the case of small pipes, which nearly always have flanges fixed by screwing. It seems on the face of it to be wrong that holes should be made in a pipe to be afterwards closed by rivets. A satisfactory job, however, can be made in this way, but if a rivet does leak under high-pressure high-temperature steam it is almost impossible to make it tight. Undoubtedly, the greatest drawback is the presence of rivet heads inside the pipe, which, coming very close together, seriously reduce the area of passage. With high-velocity steam this either means a continuous loss due to a greater pressure drop, or a larger-sized pipe to pass the same weight of steam, with resultant loss in working due to increased radiation surface and higher capital outlay.

There is more than one method of welding flanges to pipes. The oldest and cheapest is to heat the pipe and flange in a furnace to a welding heat, and to make the weld by hammering either by hand or by machine. To control the temperature in order to obtain a welding heat on the thick flange at the same time as on the thin pipe is by no means an easy operation, especially with the larger sizes of pipe, and the risk of failure with this method is so great that this type of welding should never be used with steam above 100 lb. pressure.

The only entirely satisfactory method of fastening flanges to pipes is by welding them on by means of the carbon-arc process. A continuous weld should be formed right through the flange from back to front, and in addition a good fillet should be worked up at the back of the flanges. As this is a process of building up the weld bit by bit, it takes considerable time, and demands skill on the part of the operator, but it should be pointed out that he is able to control the work and the temperature quite easily at every instant, provided he is given the right current, the right type of machine, and the right materials to work with.

Riveting is highly skilled work, for under existing conditions it must be perfect from the start. In the days of low-pressure saturated steam, free use of caulking would make almost any rivet tight and would cover up bad work. This is far from being the case with high-pressure conditions. In the early days of welding it was very difficult to prevent testers caulking up a pin-hole leak in a weld, for a soft weld lends itself to this treatment, but highly superheated steam soon finds out the weak places, and trouble results. To attempt to caulk a leaky weld is very short-sighted policy, although it seems to be such an easy way out of the difficulty. An argument frequently used against welding flanges by any process is that so much depends upon the human element, but is this more so with welding than with most engineering work, or than with riveting?

In the past the regulation of the current, and consequently the temperature, depended upon the length of the arc maintained by the welder, a very delicate operation, and one which by the very nature of things was constantly varying with the physical condition of the man, but with specially designed plant the current remains constant within wide ranges of arc, and so the regulation of the temperature does not now depend so much upon the operator.

But accepting that there is as much possibility of trouble with riveted flanges owing to poor workmanship as with welded ones, it is contended that, however badly riveting may be done, no serious accident can happen, as the flange cannot be blown off, whereas such a thing might happen with bad welding. It certainly could happen, but except with fire-welding it is not at all probable that it would happen, and so far as I know never has happened with a carbon-arc welded flange. If the process of welding be considered,

* Paper read before the Institution of Engineers and Shipbuilders in Scotland on March 3, 1925.

it is easy to see why this should be so. The welding is done piece by piece, and the welder goes round the flange adding the metal in layers. By carelessness he may fail to make a weld in places but it is highly improbable that a competent man could do his work so badly that the flange would be liable to come off and yet pass the hydraulic test, hammering under pressure, and close inspection both under pressure and after the blanks were taken off. It is not difficult to see a bad weld after the flange has been faced.

Having fastened the flange to the pipe, the next important question is how to make the joint. Many methods are employed to accomplish this, but before considering them some essentials of a good joint, whatever the method adopted, may be enumerated. The flanges must be heavy to reduce to a minimum the probability of springing, the joint must be made on a raised face inside the bolt holes, and a ground face is very desirable, though not essential. There is no mystery about the making of high-pressure joints. By care, experience, and the use of good materials, joints made by the same methods as have been used for many years are giving satisfactory service to-day, that is to say, with an ordinary corrugated metal ring and a wash of thin cement. Many such joints, subjected to the working conditions of a large power station, have been in use for over two years, and have never been touched since they were made, but it must be added that in the original lay-out of the piping expansion stresses were reduced to a minimum and every care taken to prevent water collecting in the pipes. Expansion stresses and water are the two great enemies of pipe joints, and water is by far the worst.

The effect of water on joints, subjected alternately to high-temperature steam and water, is to set up a chemical action with the paste used for the joints, and so to produce a slight acidity in the water. This acidulated water seems to set up electrolitic action, which quickly destroys the joints. It has not been found possible to make a paste which will not be affected by the action of water and at the same time be satisfactory in all other respects. No good joint can be made with the wrong type of bolt. Bolts made from steel of from 30 tons to 35 tons tensile strength have given most satisfaction, and have been adopted as a standard. Bolts made from high-tensile steel have shown a liability to brittleness after being subjected to variations of temperature.

Where branches have to be taken off pipes this should be done by means of welded-on stools, and experience has shown that the oxy-acetylene process is the most suitable for this work. At one time branches were welded on by the carbon-arc process, but, though to all appearance the weld was quite normal, it sometimes broke down under test, and as there was a possibility that one such branch might pass the test and yet break down in working, the risk was considered too great, so this process was given up. Oxy-acetylene welding is more expensive, but it has given no sign of failure in working. In branch welding there are only two thin pieces of metal to be dealt with. Therefore, the period during which the full temperature of the carbon arc can be kept on the metal with safety is very short. This is possibly the root of the trouble, and, if so, it is inherent in the process. The branch piece is not taken through the pipe because it is necessary to get access to the joint from the inside both with the blow-pipe and with the hammer, and as this can often only be done through the branch, the joint must be inside the branch. Cast-steel tees must be ruled out of this class of pipework, as well as riveted stools, owing to the fact that they are usually riveted by hand, are too often not satisfactory, and, as they can only be fixed near the end of the pipe, they cause many otherwise unnecessary joints in the main. It is advisable to have as few joints as possible. With simple design and large units, it should be possible to do away with branches, and to bring the pipes into vessels which serve as collectors and distributors as well as drainage points. Collector vessels should be placed with the axis vertical, for in this position it is easier to arrange the position of the branches and the drainage, and vessels so placed are not subject to hogging stresses, which are prevalent in vessels placed horizontally when water accumulates in them.

The separation of water from steam is no new thing. A simple reversal of flow is all that is necessary, and complicated arrangements of baffles and spirals are quite out of place. There should be no joint in the water-space of a separator; indeed, it is best to have no joint whatsoever in these vessels. For this reason, welding is by far the most satisfactory method of manufacture. Welded throughout, large vessels of this type are working at the highest pressures, and are giving entire satisfaction, which cannot be said of riveted vessels working alongside them and subject to exactly the same working conditions. Welded vessels have been in use for 15 years at pressures up to 200 lb. per square inch, but when an attempt was made to apply much higher pressure to this class of vessel it was found from experiment that the methods of manufacture, although fundamentally the same, had to be modified to suit the altered condition. As a result of these modifications, it may be said that vessels manufactured for high pressures have a far greater margin of safety than those formerly made for lower pressure. This illustrates the fact that no method of welding is suitable for all conditions, for the body seam is welded by the water-gas process, the ends and the flanges by the carbon-arc process, and the branches by oxy-acetylene. As the walls of the vessels are thick and the body is large enough for a man to get inside, the branches are carried through the wall, and are welded both on the inside and outside.

Nothing need be said about supports, as no new problems have arisen, and drainage and covering are subjects far too important to be dealt with at the end of a paper. It may be said, however, with regard to covering, that great care must be taken in the selection of suitable materials, and samples of the materials to be used should be tested both for quality and for duty. Such tests can now be carried out at the National Physical Laboratory.

I may sum up by saying that no drastic alterations are necessary either in materials or in the method of manufacture to meet modern conditions in piping, but great care and experience are essential in all departments of the work, especially in design. An eminent engineer said lately that there were so many places in a power station where trouble might arise that he did not intend to have any with pipe-work; in fact, he wished to, and did, forget all about it. This desirable position can be realised, but not if the pipe-work is forgotten or treated as a very subordinate consideration in the design of the power station. There is food for thought in the fact that pipework is the only important part of a station which the manufacturer is not expected to design, and, further, that in many cases he does not even come into direct contact with the engineer at all. This is not altogether right. The experience of the pipemaker should be used by the engineer, as the pipe contractor cannot be expected to guarantee the successful working of the plant or the duties to be obtained, unless he has been consulted during the design of the lay-out. The final word is, put more responsibility upon the pipe contractor, and exact from him as definite guarantees as are exacted from the maker of any other plant, and if competent, he will gladly undertake it.

THE ROYAL METEOROLOGICAL SOCIETY.

AT a meeting of the Royal Meteorological Society, held on the 18th ult., at the Society's Rooms, 49, Cromwell-road, South Kensington, a paper, entitled "*The Effect of Pressure Distribution upon London's Sunshine in Winter*," was read by Miss L. D. Sawyer. The results contained in the paper were obtained from an analysis of the pressure types experienced during the five winters ending 1921–22, and the amount of sunshine recorded in different parts of London each day. Near the centre of a depression the average sunshine was found to be less than 0·5 hour per day, and near the centre of an anti-cyclone the figures were equally poor, except with east-south-easterly breezes. Provided, however, that the pressure centre was at least two or three hundred miles away, the average with anti-cyclonic conditions appeared about two and a-half times as great as with cyclonic, while what has been termed a "neutral distribution," neither cyclonic nor anti-cyclonic, was almost as sunny. The importance of the relative positions of high and low pressure was considered, as exemplified by the dullness of north-easterly winds in all types. In a comparison of London records with those from South Farnborough it was shown that Hampstead and Greenwich were both almost as sunny as South Farnborough when the air reached them before passing over London, but Hampstead lost over an hour a day with south-easterly winds and Greenwich as much, or more, with north-westerly winds.

A second paper, entitled "*On the Changes of Temperature in the Lower Atmosphere, by Eddy Conduction and Otherwise*," was read by Professor S. Chapman, F.R.S. It stated that for a number of years hourly observations of the temperature of the air had been made on the Eiffel Tower, at the base, the top, and two intermediate heights. These observations were almost unique in kind and constituted valuable material for the study of the mode and causes of change of temperature in the lowest stratum of the atmosphere, 300 m., or nearly 1,000 ft., thick. Studies by previous writers had been made, in one case on the basis of the assumption that conduction by whirling eddies was the predominant cause, and in another case adopting the hypothesis that radiation also played a part, which was assumed to be of the same kind and magnitude at all heights in the layer. The present study, executed by a different method, appeared to demonstrate that eddy conduction was not the predominant cause of the temperature changes, and that the effect of the remaining (major) cause, probably radiation, was far from being constant with respect to height. The temperature changes wrought by conduction were greatest at midday, and small at night; those produced by radiation were greatest soon after dawn (when the air was being heated rapidly) and in the late afternoon (when the air was cooling).

CATALOGUES.

Stone Breakers.—Messrs. Hadfields, Limited, Sheffield, have sent us a copy of their catalogue of machinery for breaking, crushing and elevating stone and ore. Several types of machines dealt with cover all ordinary requirements.

Circuit Breakers.—The English Electric Company, Limited, Queen's House, Kingsway, London, W.C., have sent us a copy of the new edition of their catalogue of ironclad oil circuit-breaker pillars designed specially for use where the amount of power to be interrupted is not very large.

Valves and Meters.—Two folders forming indexes to their detailed general catalogues have come to hand from the associated firms, Messrs. George Kent, Limited, and J. Blakeborough and Sons, Limited, 199, High Holborn, London, W.C. I. One of the folders relates to valves and the other to meters.

Electric Generators and Motors.—A new edition of their catalogue of medium size continuous current generators and motors, issued by Messrs. Bruce Peebles and Co., Limited, Edinburgh, contains complete specifications of the machines with tables of weights and dimensions in British and metric units and also tables of ratings, speeds, efficiencies, &c. Machines with all the usual types of protection are referred to in the catalogue, which also deals with vertical spindle motors.

Winding Engine.—A very full description of a winding engine supplied to Messrs. Barker and Walkers' colliery at Bawtry, Yorkshire, by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, has been issued by the latter firm. The winding drum is driven by two electric motors, supplied with current from a turbo-generator regulated on the Stubbs-Perry system. The peak power developed is 6,000 h.p. The shaft sinking operation is also described generally, with some particulars of the plant used, and the publication will be of exceptional interest to mining engineers.

Repetition Lathe Work.—A catalogue of some seventy varieties of tool holders—mainly for use in the turrets of capstan, turret and automatic lathes or screwing machines—is to hand from Messrs. Alfred Herbert, Limited, Coventry. These products range from simple tool holders to fairly complex tool boxes having several tools with operating feed screws or levers in addition to and independent of the machine feed mechanisms. The hexagon turret carries up to six of these tools, so that a large number of cutting operations may be successfully carried out in repetition work with the same tool setting. The catalogue is likely to be most useful in the modern machine shop.

Steel Ropes.—The latest edition of a catalogue of steel ropes made by Messrs. John and Edwin Wright, Limited, Birmingham, includes 30 new patterns added since the previous edition was published four years ago, so that in all 150 varieties are now dealt with. Mining, crane work and marine equipment seem to call for the greater part of the steel ropes, while aerial ropeways, suspension bridges, steam ploughing and power transmission employ a considerable proportion. Compound hemp and steel ropes and flat steel ropes also have important uses. All these classes of ropes, in both ordinary and special varieties, are illustrated in cross section in the catalogue, which also contains tables of breaking strains, technical and practical notes and much useful information on the subject of drums, pulleys and other accessories.

Furnace-Inspection Door.—A leaflet to hand from the Pluto Engineering Company, Limited, 2, Upper Westbourne-terrace, W. 2, illustrates and briefly describes a safety inspection door for boiler and other furnaces designed to prevent accidents from outbursts of flame and also to avoid air leakage while an inspection is being carried out. A cast-iron plate, bolted to the brickwork, has a 3-in. square opening, which is normally covered by a swinging door. As the door is swung aside to enable the interior of the furnace to be seen, a circular sheet of mica carried in a frame attached to the door, is brought into position over the opening, which is also covered by a fixed plate of blue glass. The latter is protected from the heat of the furnace by a cast-iron lid when the door is closed. Other forms of furnace equipment supplied by the company are referred to on the leaflet.

INDIAN SHIPPING RETURNS FOR DECEMBER.—The tonnage of vessels entered into British India and cleared outwards with cargoes from and to foreign countries and British Possessions during the month of December, 1924, amounted respectively to 596,000 and 687,000 as against 586,000 and 735,000 in November, 1924, and 527,000 and 647,000 a year ago. The tonnage entered into and cleared from British India during the nine months April to December, 1924, was 5,115,000 and 6,183,000 respectively, as compared with 4,965,000 and 5,790,000 in the same period last year.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

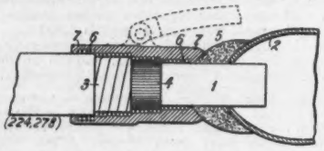
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C.2, at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

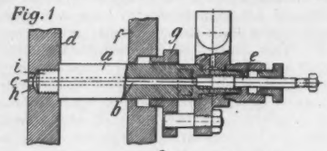
224,278. British Insulated & Helsby Cables, Limited, Prescot, J. L. Packer, Prescot, and C. Vernier, Gosforth. Electric Cables. (3 *Figs.*) August 3, 1923.—The invention has reference to lead-sheathed and externally-reinforced or armoured cables and to the connections or junctions of the ends of lengths of such cables. The ends of the sections of cable forming a transmission line are generally connected together in a metal junction or connecting box or case, to which the ends of the cable lead sheath are coupled up by a plumber's wiped joint. In the case of armoured cables, the armouring of the cable is removed from the sheath for the length occupied by the wipe, which is joined to it, and for a short distance backwards adjacent to the wipe in order to facilitate the wipe joint being made, and in the finished connection therefore, outside this portion, reinforcement is normally absent. According to the invention, the outer parts of the wipes and the adjacent part of the cable sheath are encased in a sleeve of lead or lead alloy, or other alloy having a low melting point, which is preferably cast round it; in the case of armoured cables, the end of the armouring itself at the ends of the cable lengths is preferably also encased in this sleeve. 1 represents the lead sheathing of the cable, and 2 is the box or chamber—that shown being in the form of a lead sleeve—the ends of which are to be connected to the sheath 1. 3 represents metal—say, steel—tape or strip armouring. 4 is the internal helical wire armouring, and 5 represents

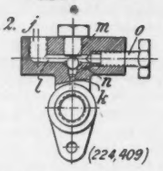


a wiped or plumber's joint connecting the end of the box or chamber 2 with the sheath 1. The helical armour wires 4 are removed from the lead sheathing, as will be seen, to a point which will be some distance away from the end of the wiped joint 5; and, in the case shown, the helical metal tape windings 3 are removed for a greater distance from the joint than the wires 4, and there are wound round the completely bared part of the sheath 1, between the end of the wiped joint 5 and armouring 4, copper wires 6; and, in the case shown, these windings are extended over the bared portion of the armouring wires 4 and the metal armouring tape winding 3. The whole of these portions of the cable, including a portion of the wiped joint 5, is enclosed and covered by a sleeve 7 of lead or lead alloy having a low melting point of a thickness such as shown, this sleeve being cast round the parts. By removing the armouring wires from the lead sheathing in the manner described, viz., to a point some distance from the commencement of the wiped metal 5, interference with the operation of making the wiped joint 5 with the sheath 1 is avoided, the plumber being able to make the joint freely and well. The lead sheath of the cable being thus unprotected or weakened by this removal and absence of the armouring as described, the required strength is made up by the lead or like metal sleeve or covering 7, and further strength is furnished, and the sheath of the cable further reinforced, by the tinned copper-wire windings 6. (*Sealed.*)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

224,409. A. L. Mellanby, Bridge of Weir, and J. S. Brown, Greenock. Internal-Combustion Engines. (2 *Figs.*) January 11, 1924.—The invention relates to the indication of the mean pressures occurring in internal-combustion engine cylinders. In accordance with the invention, the pressure at the desired point of piston travel is transferred to a gauge through a pipe connection from an opening made through the cylinder wall at the required stroke location and a non-return valve opening towards the gauge is fitted on the connecting pipe. The fitting shown comprises a metal body *a* which is drilled axially throughout its length to provide a small bore *b*, the inner end of which registers with a corresponding bore *c* in the cylinder *d*, whilst the outer end of the bore *b* is enlarged to receive the spindle *e* of a shut-off valve. Where the body *a* passes through the cylinder jacket *f* a packing gland *g* is provided so as to prevent the escape of the cooling water, whilst the cylinder liner *d* is recessed, as at *h*, to receive the inner end of the body *a* which is reduced, as at *i*, for this purpose. The bore *c* is drilled so as to correspond with a predetermined point in the piston travel, the combustion pressure at this point being used as an indication of the mean-effective pressure. The combustion pressure at this point is indicated by a Bourdon or other pressure gauge which is adapted to be screwed into the connection indicated at *j* in Fig. 2. The bore *b* communicates with this connection *j* by means of branch passages *k*

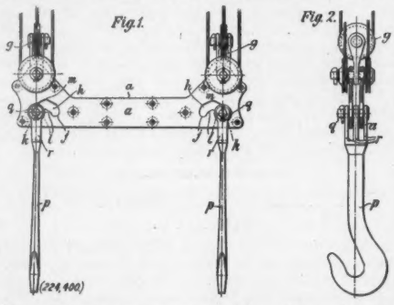




and *l*, between which is interposed a non-return valve *m* A bye-pass *n* controlled by a needle valve *o* is provided for the purpose of cutting out the non-return valve *m* when necessary. (*Sealed.*)

LIFTING AND HAULING APPLIANCES.

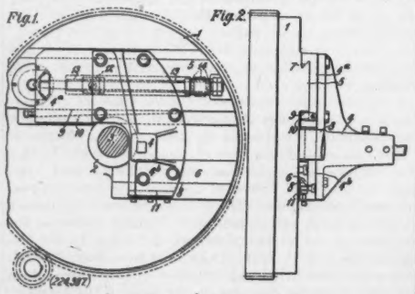
224,400. C. Moody, Middlesbrough, and Dorman Long & Co., Limited, Middlesbrough. Lifting Beams and Hooks. (3 *Figs.*) December 21, 1923.—The invention relates to lifting tackle of the kind in which a transverse beam has depending hooks which carry the load, one or more of the hooks being provided with alternative seats or points of suspension from the beam whereby one set of hooks, while in a vertical position, may be employed for lifting heavy objects of different sizes. The beam *a* is supported by lifting tackle *g*. Provided in each end of the beam is a slot *h*. The inner ends of the slot *h* terminate in semicircular recesses *j* and the outer ends in similar recesses *k*. The parts *l* of the slots slope upwardly and meet at a point *m*



midway between the recesses *j* and *k*. A hook *p* depends from each slot *h* by means of a circular pin *q*, which passes through the slot *h* in the beam and through three perforated arms *r* formed on the end of each hook. The recesses *j* and *k* form seats in which the pins *q* rest, and, consequently, provide two positions from which each hook may depend. When it is desired to transfer the hooks from, say, the outer seats *k* to the inner seats *j*, the beam is lowered until the lower ends of the hooks are supported by the ground and the pins *q* have passed up the inclined parts *l* of the slots and are at the highest point *m*. The upper ends of the hooks are now leaning towards the inner seats *j*, and on raising the beam they will fall into the seats *j*. (*Sealed.*)

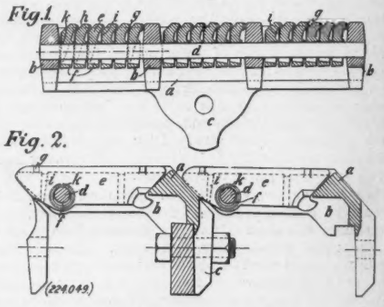
MACHINE AND OTHER TOOLS, SHAFTING, &c.

224,387. A. B. Clements, Dumbreck, Glasgow. Boring and Facing Machines. (2 *Figs.*) November 29, 1924.—The invention relates to boring and facing machines of the type comprising a tool-box-carrying head-stock having a centrally bored supporting spindle adapted to carry a boring bar and a tool-box adjustable transversely of the head-stock. The invention provides an arrangement whereby the necessity for forming the tool-box as a fork is avoided. The tool-box-carrying head stock 1 has a centrally-bored supporting spindle 2 adapted to carry a boring bar 3 and a tool-box 4 adjustable transversely of the head stock, the arrangement being such that the operations of boring and facing may proceed concomitantly. The head stock 1 is provided with a main slideway 5 disposed on one side of the centrally-bored spindle 2, and a supplementary slideway 6 is disposed on the opposite side of the spindle 2. The tool box 4, mounted on the slideways, is of L-shape configuration, the major limb 4^a engaging the main slideway 5 and the minor limb 4^b engaging the supplementary slideway 6. It will be seen that the disposition of the slideways, and that of the tool-box, are such that the spindle 2 is located in the space contained by the limbs 4^a, 4^b. The outer edge of the main slideway 5 is bevelled at 7 to receive the correspondingly bevelled face of the tool-box 4 and the outer face of the supplementary slideway is similarly bevelled at 8, the inner face 9 of the main slideway being unbevelled. Adjustment of the tool-box 4 on the slideways is effected by the operation of a wedge 10 slidable on the tool-box 4 and acting on the unbevelled face 9 of the main slideway 5, and by the operation of a jaw 11 acting on the bevelled face 8 of the supplementary slideway 6. For imparting feeding movements to the tool-box 4 across the head stock 1, there is provided a nut-forming element 12, secured to the tool-box 4, and a leading screw 13 in engagement with the nut-forming element and mounted in bearings 14 for rotation on the head-stock, the leading screw 13 being operated by suitable gearing of well-known type during rotation of the head-stock. (*Sealed.*)



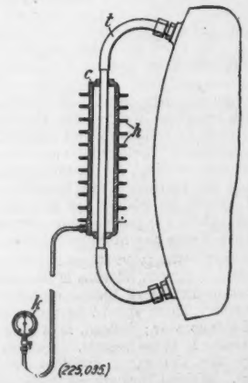
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

224,049. The Underfeed Stoker Company, Limited, London, and P. W. Brown, Derby. Mechanical Stokers. (4 *Figs.*) September 21, 1923.—The stoker is made up of a number of grate bars *a* having cheeks *b* and a flange *c* which is bolted to the bar of the stoker chain. The cheeks *b* carry the pin *d* on which the grate members *e* are threaded. It will be seen that the perforation *f*, which allows the threading of the grate member, is conical; also that each member has a rounded boss *g* near each end which is adapted to rest against the



inclined face *h* of the next member. The air-space thus secured is also maintained by ribs *i* on the other side of the member. Owing to the bosses *g* and the ribs *i*, the members may swell or grow considerably without choking the air spaces, and since the point *k* at which the member is supported is offset from the vertical line through the centre of gravity of the member, the constant position of the latter resting against its neighbour, or against a cheek *b*, is ensured. (*Sealed.*)

225,035. G. and J. Weir, Limited, Cathcart, Glasgow, and The Right Hon. William Douglas, Baron Weir of Eastwood. Boiler Water-Level Indicator. (1 *Fig.*) November 1, 1923.—The invention consists of a boiler water-level indicator comprising a tube *t* connected to the boiler above the maximum water level and below the minimum water level, an hermetically-



sealed vessel *c* which envelopes the tube *t*, or the portion of it between the said levels, the vessel *c* containing fluid, means, such as gills *h*, being provided for encouraging the dispersion of heat from the vessel *c*, and a pressure-indicating gauge *k* connected to the space inside the vessel *c* and outside the tube *t* so as to indicate the pressure in this space. (*Sealed.*)